approach

JANUARY 1967 THE NAVAL AVIATION SAFETY REVIEW

By Earl J. Sands, Ph.D.
Head, Human Factors Engineering
Lockheed-California Company

THE ROLE OF VISION

Why Midair Collisions?

Midair collisions still remain one of the most critical areas of concern in aviation safety. Despite improvement in most other aspects of flying, there has been relatively little reduction in the number of midair collisions. Approximately 40% of all midair collisions result in the loss of one or more lives.

With military aircraft flying at higher speeds and in an ever increasingly crowded sky, the problem is one which conceivably can become even worse in the future. Since most midair collisions involve human factors causation, it is a problem which can be effectively contained by the application of a few common sense principles and by a thorough understanding and utilization of one's full visual capabilities.

In any pilot activity associated with the operation of aircraft, there are three sequential steps

Most midair collisions occur during conditions of good visibility

that must be followed. These are: perception, decision, and response. In order of frequency, the errors committed in midair collisions fall into the same sequence. The greatest number of errors are related to perception, the second greatest to decision and the third greatest are related to errors in judgment or responses. Every pilot should be familiar with the role of perceptual errors in midair collisions and should be aware of what he can do to minimize such errors.

Vision plays the dominant role in perception. "Seeing an aircraft" is basically a function of visual acuity. A pilot cannot take action to avoid another plane if he does not see it. But as everyone knows, pilots on the average possess exceptionally good eyesight. Why, then, does a pilot not see an object as large as another airplane rushing toward him on a collision course?

Every pilot should have an appreciation of the limiting factors in his perception that confront him every moment he is flying and may prevent his seeing another aircraft until it is too late. These factors are: high speeds, altitudes, accelerations, pilot work load, traffic density, complicated instrument panels, and even the structure of the aircraft itself. Such factors create serious visual problems for the pilot and crew of high-performance aircraft. The most critical of these is high speed.

At the speeds flown by today's jet aircraft, a perfectly ordinary situation, such as sighting another plane a mile away, can result in a collision before either pilot can do anything about it. As speeds increase, the pilot's ability to react in time decreases in proportion. The basic limitation is simply that a man cannot see, identify, or act on an object the instant it comes into his field of view. Each of these human processes takes time, usually an exceedingly short interval, but worth hundreds or thousands of feet in a high speed aircraft.

The reality of visual limitations is attested to by the fact that most midair collisions occur during conditions of good visibility. In fact, over a period of eleven and one-half years, a study of accident data by the USAF showed that approximately four out of every five midair collisions occurred under visual contact conditions during daylight hours. The majority of these accidents happened within 20 miles of an airdrome. The type of mission and violations were but minor factors. Faster planes were not overtaking and colliding with slower aircraft. The majority of midair collisions occurred between aircraft of the same type and model. Collisions which occurred during formation flying were primarily the result of faulty distance rate-of-closure judgments on the part of the pilot. Other midair collisions were usually the result of the pilot's inability to perceive another aircraft on a collision course and to react in time to avoid the collision under high rates of closure.

Speed limits the amount of available reaction time to the pilot even in the subsonic range. Consider the pilot flying at 600 mph. Another aircraft comes into his extra-foveal vision—the corner of his eye. He will travel 88 ft before he even "sees" it due to the time it takes to transmit the image from the retina to his brain. He has traveled 920 ft before he has perceived or recognized it, i.e., before he has decided whether it is a cloud or another aircraft. He has covered 2680 ft by the time he has decided whether to climb, descend, or bank to the right or left. He has traversed 4792 ft before he can actually change his flight path.

For two aircraft on opposite courses, the distances they travel relative to each other would of course be doubled. The closure rate would be 1200 mph. The distance between them would be reduced by almost two miles before either could change his flight path.

Stated another way, at 600 miles an hour, at least one of the pilots would have to see the other 9584 ft away, at the very minimum, before he could change his flight path to avoid collision. Furthermore, these figures assume ideal conditions—clear day, alert, experienced pilots, no distractions.

Table 1 presents these data in greater detail for

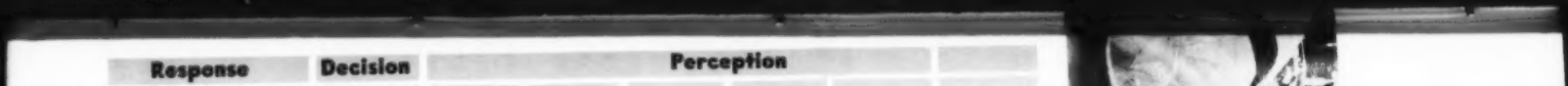

Response
Decision
Perception

TABLE I

TIME INTERVALS REQUIRED BETWEEN FIRST SIGHTING OF OBJECT AND CHANGING FLIGHT PATH TO AVOID AND DISTANCES TRAVELED IN THESE INTERVALS

		Time in Sec		Distance Traveled in Feet			
				Closing at 600 MPH on Stationary Object		Two aircraft closing at 1200 mph	
	Operation	For Operation	From 1st Sighting	During Operation	From 1st Sighting	During Operation	From 1st Sighting
Perception	Sensation (light travels from retina to brain)	0.10	0.10	88	88	176	176
Perception	Motor Reaction to Pre-arrange Eye Movement	0.175	0.275	154	252	308	484
Perception	Eye Movement	0.05	0.325	44	286	88	572
Perception	Focusing with Fovea	0.07	0.395	62	348	124	696
Perception	Perception (minimum recognition)	0.65	1.045	572	920	1144	1840
Decision	Deciding What To Do (estimated minimum)	2.0	3.045	1760	2680	3520	5360
Response	Operating Controls	0.40	3.445	352	3032	704	6064
Response	Aircraft Changes Flight Path	2.0	5.445	1760	4792	3520	9584

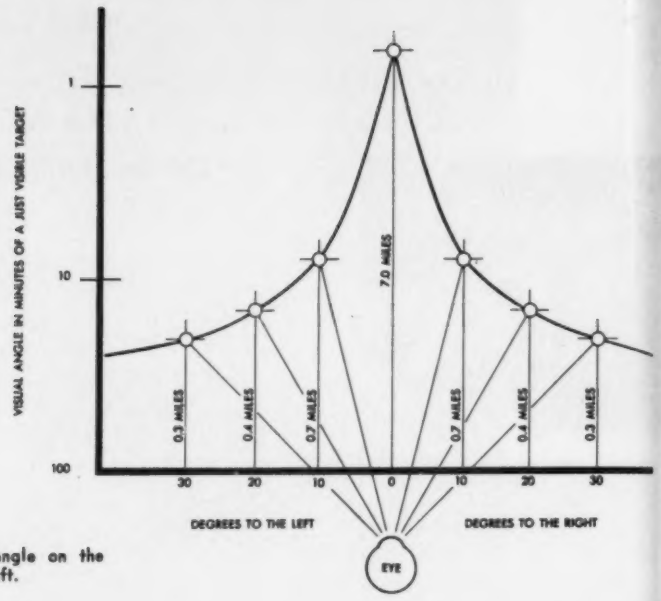


Figure 1. This is the effect of offset viewing angle on the detection distance for fighter size aircraft. NOTE minutes-mile ratio.

both cases, i.e., approaching a stationary object at a speed of 600 mph and approaching another aircraft head-on, which is also flying at 600 mph resulting in a 1200 mph closure rate.

Surely a pilot can see another aircraft when it is only two miles away in clear daylight. In fact, considering visual acuity only, a pilot can see a fighter on a head-on course at a maximum distance of seven miles, but only under the following highly favorable conditions:

- Bright daylight
- High brightness contrast between the oncoming aircraft and its background (sky, clouds or earth)
- The pilot is looking directly at the other aircraft
- The pilot's eyes are focused for distance vision

While most pilots are well aware of the need for daylight lighting conditions and the importance of contrast, the latter two conditions named may be less familiar to them. The condition that the pilot be looking precisely in the direction of the other aircraft refers to the fact that visual acuity reduces rapidly as the image moves away from the center of the visual field.

A cone with an apex angle on the order of one degree encompasses that portion of the visual field where maximum visual acuity is attained. As shown in Fig. 1, the pilot will pick up another aircraft at the maximum distance only if he happens to look or fixate his eyes within a degree or so of its position. As an oncoming aircraft approaches (but is further away from the center of the pilot's visual field), it must be nearer to the pilot to be detected by him. For example, if the aircraft approached at an angle of only 10-degrees off the pilot's central vision axis, the oncoming fighter would only be .7 miles away from collision before he detected it. That distance is the equivalent of 3696 ft.

Comparing that distance to the values shown in Table 1 for 1200 mph closure indicates the pilot would be in the process of deciding what to do when the collision occurred.

The last condition, that the pilot's eyes must be focused for distance vision, results from the normal tendency of the eye to focus for near vision when it does not have a specific distant object upon which to focus. This occurs most frequently when searching for objects in a clear sky. This near-focusing tendency will generally result in failure to detect aircraft at maximum distance (or elsewhere), even if all other conditions are favorable. The phenomenon is called "empty field myopia."

The critical importance of the limiting factors on pilot visibility is pointed up by a special study using commercial airline pilots, flying cross-country in daylight, with ceiling and visibility unlimited. During the flight, other aircraft were put on collision courses with the aircraft flown by the pilot under test. Ap-

propriate safeguards were provided. The significant result, for purposes of this discussion, was that while the target planes could be detected by observers, who were informed of their courses, at 10 to 12 miles, the pilots failed to pick up the target planes until they were three to five miles away—until they were at about one-third the maximum detectable range.

Now if we apply the same ratio to the maximum distance at which a fighter-size aircraft can be seen —seven miles when in a head-on course—the distance at which the pilots will detect each other could be as little as 2.3 miles. If the closure rate of the two craft is 1200 mph, i.e., each airplane flying at 600 mph, as stated earlier at least one of the pilots must detect the other aircraft nearly two miles away to avoid a collision. It should be evident that the safety margin in such a situation is critically small—one-third of a mile or approximately two seconds. It seems clear that the human eye has some basic limitations which make it unreliable as a collision warning device under daylight VFR conditions.

What can the pilot do to reduce the hazards of midair collisions?

While awaiting the development of an advance in the state-of-the-art that will solve the problem of daylight air-to-air visibility, there are several things the pilot can do to increase the probability of detecting another aircraft on a collision course. The first thing a pilot can do is to develop a better understanding of the limitations of his visual apparatus as an aircraft detection system. Second, he can make better use of the time spent in scanning. *He should scan systematically over the entire area from which threatening aircraft are most likely to come. Normally, this will be an area fairly near the horizon.*

The distance to scan on either side from dead ahead will depend somewhat on his speed.

At high speeds the greatest danger area is a narrow cone directly ahead.

At slower speeds, the danger area extends much farther out to either side and includes the rear as well. He also should avoid spending too much time scanning a limited area—this results in neglecting other areas which should be covered. Finally, he should not rely on peripheral vision to keep him out of trouble. As was shown in Fig. 1, when a fighter-sized aircraft is detectable in the pilot's peripheral vision, the chances are that he has no time left to avoid it.

Here are some final points to keep in mind:

1. Practice good eye hygiene at all times; avoid infections, injury, and irritations to the eye.
2. Use authorized sunglasses for proper filtering of light.
3. Maintain optimum physical health, including adequate nutrition.
4. Maintain a visual lookout at **all** times when visibility permits.
5. Do not operate in reduced visibility **except** under positive control.
6. **Know** and **use** standard formation procedures and signals.
7. **Keep alert!**

It Could Ruin Your Whole Day

By LCDR Donald H. Gehring
ASO, VP-5 NAS Jacksonville

It is now about 1900W, Lt W. T. Door as PPC and his faithful copilot companion, LTJG Ramey Smith have just finished a thorough preflight and obtained a detailed weather briefing for their flight from Salamander, Sasnak to Chemelienne, Kroy Wen. Meanwhile, the third pilot, Lt Lance Smith, a qualified PP2P and the brother of the copilot had just finished preflighting Buno 131799, an SP-2E with all the latest service changes incorporated, and was completely satisfied.

Lighting up a fag from his deck of Luckies at 50 ft from the aircraft, Lance checked with the plane captain who said that every piece of gear was 4.0 and the plane was ready to go.

The weather was cold and dusty with a high full moon at Sasnak but warm and muddy at Kroy Wen. A cold front was approaching Kroy Wen. The weather guesser predicted that the flight would enter

this front about three hours after T.O., and would be in it for about 30 minutes before the weather cleared again. This would occur about one hour from their destination.

After the fire guard was posted, the engines started and thumbs-up was given for all systems "go," clearance was copied and read back correctly, giving the flight a takeoff of thirty seconds earlier than originally scheduled. After contacting departure control we came up on airways.

"Boy what a beautiful night!!" exclaimed Ramey!

After about two hours out, Ramey said, "Jack, our omni is out; Radio, check the circuit breaker."

"Sir, the breaker is out and won't stay in but no sweat," said Jack, "we still have tacan and birddog." "Ramey, notify center that we'll continue without VOR."

"Roger," said Ramey. "Boy, look at this classic front. The clouds are building just like in the book. Aerology said it should last for about 30 minutes and so far he's been right on the money."

Ramey then called and advised that his omni was out and requested to be cleared to continue via flight plan route using tacan. (It so happened that every facility was a vortac facility and there were frequent UHF and LF homers enroute.)

"Well, for a cold front, it sure is smooth. Guess I'll turn off the Grimes light since it's even making the autopilot dizzy. CAT 28° and looking good," Ramey remarked to no one in particular.

"Sir, are you sure it's OK to punch the varicam while on autopilot?" asked the plane captain.

"Heck yes, it gives a little more airspeed when you get the varicam trim to zero."

The pilot, with nothing to do now, sat back and began to notice his discomfort. "Hey Lance, turn on the cabin heater . . . I'm getting cold." "Plane captain, check the control surfaces and props for icing."

"Roger, sir, we're starting to get a bit of light rime ice on the wing roots and . . . sir, it's building up a bit faster now."

"Roger; Lance, fire off the wing and empennage heaters; Ramey, short cycle on the props!"

Lance said, "Heaters operating normally and both A and B phase currents check O.K."

"Pilot, port recip oil temp rising and the cooler door is full open . . . cylinder temp starting to rise also."

"Roger; Ramey, jets; plane captain check me; rich, retard, props 2600, No. 2, 48 in. Hg, sync off; No. 1 throttle closed; No. 1 mixture cut off. Feather No. 1." "Pete, jets to 94 percent, secure No. 1 by the check list and notify center of our difficulty. Number 2 recip power set with our handy dandy chart, secure starboard jet. Oh boy, Ramey, also advise them of our new TAS of 201 kts." (It was now so dark and cloudy that the jet dumping could not be seen.)

"Roger, Jack." "Kroy Wen Center, this is Navy."

"Pilot, plane captain, generator out and won't reset. Do you want the *Flight Manual?*"

"No, lighten ship, throw it overboard."

"Crew, Pilot, secure all d.c. equipment; in a moment I'm turning off the battery and there'll be no ICS and only the dome light for you, so stand by with the candles."

"Wow, what a zoom when the autopilot disconnected," someone exclaimed!

"Plane captain, Pilot, what happened to my tacan—it's a.c., isn't it?"

"Sir, a.c. is d.c.-controlled, we'll need the battery ON."

"Roger."

"Ramey, continue on your G-2 and peanut alternator . . . you have d.c. essential and Emergency Inverter ON." "We'll fly this heading and should break out of the clouds in about 10 minutes."

"Pilot, plane captain; all d.c. equipment secured —pilot, the Jez operator is being electrocuted at the omni receiver—he was checking it because he thought it caused No. 4 to go off the line."

"Awe, lousy stray unknown a.c.—a.c. generators OFF . . . take a dry cloth and lasso him free but don't touch him until he is free." "Aft station . . . Damn ICS . . . *Nav, have aft turn on the oxygen system and jam a hose in Jez's mouth and make him breathe, smoking lamp is out.*" (By now the pilot could be heard clear back to the radio compartment.) . . . (Jez finally revives.)

"Pilot, Navigator; heaters have stopped working—must be the a.c. ignition failure—Prop de-icers inop too."

"Roger, Nav; awe nuts, birddog out to . . . it's entirely d.c. but the needle is a.c. operated. Ramey, we'll fly for five more minutes on this heading, but use the wet compass—I'm securing the emergency inverter to save the battery. Later, I'll turn the battery ON and get a tacan fix if the a.c. comes on."

"Roger, Jack; . . . Hey, we're losing altitude and airspeed—we're icing pretty badly and the No. 2 recip is vibrating a bit."

"Roger; plane captain, pull the fuel shut-off circuit breakers on the port and starboard jets just in case the service change hasn't been installed." "Battery ON, Ramey, start the starboard jet if you can but

"Feather No. 2 and secure it with the check list . . . ."

don't crank it." "Plane captain, change RPM on No. 2 recip and see if that will fling the ice off."

With both jets now on the line, the plane captain was continuing to rev No. 2 recip when suddenly he reported, "Sir, revving No. 2 seems to have caused the a.c. disconnect warning light to come on."

"Disconnect . . . BMEP too nervous to observe a rise . . . Aw, what are the other indications? . . Blast this a.c. lash-up."

"Pilot, plane captain; loud noise and vibration . . . No. 2 seems to be tearing itself up."

"Feather No. 2 and secure it with the check list. Give me a nacelle check."

"Sir, no smoke or fire from No. 2 but there's a lot of oil running aft."

"Crew, prepare to bail out."

All of a sudden Ramey cried out, "Jack, we're in the clear and there's a field right below us."

"WAHOOO-Ramey, circle the field. Plane captain, I think maybe the oil temp on No. 1 recip went up because the oil cooler was too cold and all the oil was bypassing the cooler. Should we give it another chance?"

"Yes sir!"

"OK, make sure all d.c. equipment is OFF." "It is." "O.K. battery ON, unfeather No. 1 Recip."

"HOOHAAH, she's windmilling . . . oil and fuel ON." "Where's the check list?" "Great, No. 1 is back on the line, d.c. generator ON, system voltage normal and engine running smoothly—we must have flung off all the prop ice." "Ramey, UHF guard, Mayday, we're coming in."

Finally, after many tense minutes of letdown, a long squeek, then another and finally a thunk was heard.

"Thanks be to Almighty God."

The End

Could it happen? Who knows? Anyway, the story was written with several thoughts in mind.

Pilot and crew training are especially important in an 'old bird' with as many service changes as the SP-2E has. VP-5 used this story to impress its pilots with the urgent need to continually study NATOPS and certain portions of the Manual. After a service tour as long as this plane has had, many old wives tales crop up. Note the lack of understanding displayed by the pilot regarding weight and balance vs. performance and his dangerous use of varicam while using 'George.' Note also how well the situations were handled when the proper procedures were adhered to.

Granted, Patron FIVE is the last Fleet activity to use this model but, the model will *still be around for many years* in the Reserves. Perhaps the Reserves could make some use of this story to motivate their flight personnel to continue to study.

In summary, the Reserves will be using the 'E' and several Fleet squadrons the "H" for years to come.

It cannot be stressed too much to flight crew personnel that they must continually study and restudy their aircraft—especially if it's been around for a while.

'You, too, can be a 97 po

New Problems:

This is not a flight surgeon's lecture to our airborne people on the care and cautious feeding of expanding waistlines. Nothing in this article refers to calorie control (although reasonable attention to detail in this department certainly will make the problem discussed easier to live with). This is a flight surgeon's warning, however, concerning potential consequences to the aircrewman, if he is careless about how he dresses for flight.

The problem, simply stated, is this: The average naval and Marine Corps aircrewman now engaged in the combat situation in Southeast Asia is tending to overload his own individual frame with items of personal equipment to the extent that he could unwittingly become his own worst enemy if the operational situation suddenly goes against him. The hazards arise as a result of the weight, bulk and distribution of all this gear about his person.

The purpose of this article is to define this area of survival concern for the aircrewman as well as for his commanding officer (who has the power to "regulate as required") in hope that common sense will prevail and the avenue of corrective action will be self evident. This approach to the problem is intended to provide timely information in advance of any official directive measures which eventually may have to be formulated to deal with the hazards involved.

Definitions:

The term "*aircrewman*" refers to any individual who is part of a modern airborne weapons system, whether pilot, RIO, B/N, or crew chief drawing flight pay.

"*Personal equipment*" denotes all the hardware and other accoutrements the aircrewman wears on his person during flight to enhance his ability to perform his airborne mission optimally as well as safely, protect him during an emergency escape from his aircraft, and thereafter keep him reasonably alive and sound until he is located, rescued, and returned to a safe environment. This term thus covers everything he wears from helmet to flight boots, including all items strapped, snapped, sewn, laced, or otherwise fastened to him in between.

The comments made herein immediately concern our Navy and Marine Corps aircrews, (and their personal equipment) in relation to the current combat commitments in Southeast Asia. The conflict in Viet Nam represents an extreme environmental situation for which all of these personnel basically have been trained. It follows that the utility and application of this information, and the principles involved, are valid to every flight environmental situation all the way back to that of the training command, according to the particular operational requirements which prevail.

Observations from Viet Nam:

The material herein is based upon information gathered during two special surveys directed by the Chief of Naval Operations and conducted on the scene in Southeast Asia in Autumn 1965 and Spring 1966. The primary mission of the survey team, of which the author was a member, was to inquire into *all* aeromedical factors affecting air combat operations.

A careful evaluation of the attitudes, practices, and personal inventories of our aircrewmen concerning their personal safety and survival equipment was considered one of the essential aspects of this study. Observations in depth were made of nine deployed attack carrier airwings operating between Dixie and Yankee Stations in the Tonkin Gulf and of the four Air Groups of the First Marine Aircraft Wing ashore in South Viet Nam in the I Corps area. This included contact with 64 fixed wing attack and fighter squad-

97 pound Heavyweight!'

By CAPT Roger G. Ireland, MC, Director, ACEL, NAEC

rons and 26 other fixed and rotary wing units, totalling 90 combat committed squadrons and detachments visited.

Nearly 800 individuals were interviewed from Air Wing Commanders, squadron skippers, their pilots and aircrews to parachute riggers, maintenance personnel, flight surgeons, and all levels of supporting ship's company people with primary emphasis directed to the working level where the job is carried out in detail. Debriefings were held, following completion of this work, at all appropriate command levels up to and including BuMed, Chief of Naval Operations, and the Secretary of the Navy.

In general, it was observed that there was considerably less standardization of aircrew equipment inventories, attitudes, preferences, and practices than is the rule in a peacetime environment. Our aircrews, under fire, tend to adapt to their immediate needs on a much more personalized basis.

The concern of the individual about the adequacy of his own equipment becomes more complex the more closely he becomes confronted with personal hazard. For example, while operating from a CVA on Yankee Station, an A-4 pilot's privately estimated chances of survival over a heavily defended target in North Viet Nam are such that he may have little sympathy with remote dictation about what and how much equipment he must carry, unless that mandate conforms closely with his own concept of what he needs. He may be considerably less preoccupied with these details while flying 'In-country' missions off Dixie Station, where the ground fire opposition in South Viet Nam is markedly less. This same pilot may be the least concerned about this subject after his return to flying duties in CONUS. This is a normal psychological characteristic that should be self-evident, but has received insufficient attention. It has created problems, however, at the rear echelon

support establishment level where it is essential that *realistic* decisions are made that eventually move the complex logistic machinery of research, development, evaluation, supply, and transportation in effective behalf of the customer who flies the aircraft. Lag times involved in responding to equipment requirements can outlast a war without constant *realistic* guidance being exerted at every stage from rear echelon to the front line.

Required Personal Equipment versus 'Goodies':

It was found that some aircrewmen were carrying as much as 50 to 60 lbs of personal equipment above their basic body weight and this does *not* include the additional 40 lbs of the seat kit used. Some of the heaviest laden individuals are our A-4 pilots, for example, and it is difficult to imagine how they are being shoe-horned into their tiny cockpits. The heaviest specimens observed just naturally were nick-named "Teddy Bears" (which is adequately descriptive). *In general,* (and this was actually measured) our aircrewmen in Southeast Asia carry 30 to 45 lbs. of walk around weight of equipment on their persons. Where this weight exceeded 30 to 35 lbs., the excess consisted of what are best collectively described as "goodies" or an infinite variety of personally preferred "extras" (with some degree of survival enhancement potential, according to the individual owner). These items ranged from additional pistols and ammunition, to food, clothing, and exotic hunting and/or fishing gear, etc. The net effect now is (and this is the most important point):

The minimum weight of basically essential equipment required by the individual aircrewman—and this was found to apply for all practical purposes "across the board" to A-4, F-8, F-4, A-6, RA-5C, and A-1 types—is about 30 lbs (plus or minus two and one half lbs). This equipment is exclusive of the sea-survival items carried in various seat-kits (total weight of loaded kit about 40 lbs) which are fairly well standardized throughout the fleet. This also does not include the additional weight of goodies which ranged from 5 to 15 lbs per man with extremes to 35 lbs., according to individual whim.

The itemized breakdown (by weight) of these essential equipment items which the aircrewman carries on his back both from and to the readyroom on each sortie, is presented in Table I. Typical "Teddy Bear" configurations are illustrated in Figs. 1 and 2.

Sources of Hazard:

The safety-of-flight factors that are brought to light by this situation devolve around the weight, bulk (volumetric displacement) and mode of distribution of all these personal equipment items about the aircrewman's person. The problem areas described below appear to be fairly clear-cut. It should be emphasized that the aircrew population we are concerned with is usually faced with the requirement of being simultaneously prepared for either a land

Table I
Basic Essential Equipment Weights

Helmet and Attachments	3.50 Lbs.
Oxygen Mask, Regulator, Hose & Suspension	2.17 Lbs.
Flight Suit	1.91 Lbs.
Flight Boots (pair)	3.92 Lbs.
Anti-Blackout Suit	1.93 Lbs.
Torso Harness	3.91 Lbs.
Mk-3C or Mk-2 Life Preserver and Accessories Approximately	5.00 Lbs.
Survival Vest (empty)	1.47 Lbs.
Survival Radio Pack	3.06 Lbs.
Strobe Light	0.44 Lbs.
Pencil Flare Gun and Rounds	0.36 Lbs.
Seek Kits (2 piece)	1.60 Lbs.
Standard Survival Knife in Sheath	0.55 Lbs.
Shroud Cutter	0.38 Lbs.
.38 Caliber Pistol, Holster, Belt and 6 Rounds Only	2.90 Lbs.
Total	33.10 Lbs.

Fig. 1. A typical "Teddy Bear" configuration.

or sea survival situation (particularly during operations from a CVA off Yankee Station). Both the basic equipment and the "goodies" (exclusive of the seat kit and its contents) are mostly carried above the waist (torso-dependent) as contrasted to those items stuffed into flight suit and G-suit pockets. Most of this gear, however, is under water when the aircrewman is immersed in a sea survival situation and the small bulk, high density items may act as sinkers. The principles of *mass-distribution* apply in the former case—the *volumetric displacement law of buoyancy* applies in the latter case. The plain and simple principles of creature comfort and environmental habitability apply to the rest of the situation.

1. Fatigue.

The breakdown of an escalator in a FORRESTAL Class CVA (or the lack of one in a 27-Charley Class carrier which also may have air-conditioning problems) is a situation which will surely try the stamina of a "Teddy Bear" required to suddenly man an inconveniently spotted aircraft from a wardroom level readyroom, to a flight deck with up to 30 kts of launch wind on the bow. One to three hours later, this aircrewman's subsequent difficulties in desperately scrambling for cover on the upgrade in dense jungle bush after a parachute descent (with 30 to 50 lbs of gear on his back) and an alerted enemy baying at his heels can also be imagined. This situation prevails without the complications of wounds or other injuries involved.

2. Cockpit Fit.

Here is where the *bulk* of personal gear becomes

Fig. 2. Loaded down "Teddy Bear".

a factor. It is essential that the aircrewman feel perfectly comfortable in the seat for either a long fatiguing mission, or a short hectic one, with all gages, switches, controls, and look-see room easily available and without worry about getting "hung up" on the console or the coaming during a punch-out or crawl-free emergency egress.

3. Cockpit Escape.

This is a potentially serious problem area related to weight and mass distribution of personal equipment and investigations are now underway to determine more precise envelope information related to in-service escape system specifications based upon maximum allowable personal equipment weight and distribution. Excessive personal equipment weight distributed about the torso may compromise shoulder strap/lap belt restraint systems limitations, both static and powered (haul-back inertia reel), in a crash impact situation. Ejection seat trajectory height is dependent upon the total seat-man weight combination *including* seat kit. Uncontrolled mass distribution of personal equipment upon the aircrewman's body could shift the center of gravity of the seat-man mass away from the ejection force thrust axis to the extent that spinal injury is increased from the catapult impulse. With the advent of rocket boosted ballistic ejection-seat systems across-the-board to provide zero airspeed/zero altitude escape capability, wide excursion of the seat-man mass center of gravity due to the aircrewman's personal equipment weight distribution could initiate a disastrous "tip-off" or pitch rate development during the approximate half second of rocket motor burn time, cancelling out the required trajectory height. (A rocket motor under the seat will thrust toward the ground just as effectively as it will toward the sky.)

4. Parachute Recovery.

In addition to wrap-up, line-over, and other hazards of a parachute deployment complicated by a bad tumble or pitch rotation rate situation following cockpit clearance, excessive personal equipment weight will obviously aggravate parachute opening shock loads, descent rate, and eventual ground impact forces upon the aircrewman.

5. Water Survival.

Clearly defined hazards of excessive equipment weight and effect of its distribution have been identified. With respect to flotation requirements, it is known that a minimum of about 14 lbs. of net buoyancy is required to keep a vertical conscious survivor's head just above water in a calm sea state. What is not generally appreciated is the phenomenon prevailing in certain sea states wherein the "barely head up" survivor gets out of phase with the frequency and amplitude of the wave crests and is submerged continuously. About 30 lbs or more of *net buoyancy* is required to keep a conscious and otherwise capable survivor's head free of the water on the wave crests and in the troughs most of the time in such sea states. Thus two essential requirements exist for open sea survival: *adequate net buoyancy* and *adequate positioning* to ensure that an

Fig. 3. New SU-2 survival vest permits optimal distribution of gear.

unconscious or immobile survivor can be maintained face-free of the water. The bulk of torso distributed personal equipment will provide, by displacement, *some* flotation potential additional to that of the life preserver system used—but this may not always be an advantage due to density-volume variations of different configurations. It must also be considered that the act of raising both arms from the water (to signal for help or to grasp a rescue hoist) for example, robs the survivor of buoyancy due to the loss of volumetric displacement of his submerged arms.

The hard facts we are now concerned with are essentially these: (a) the Mk-3C Life Preserver provides about 55 lbs. of *net* buoyancy, but positioning is marginal if distribution of personal equipment is awkward above the waist (the survivor may even tend to tip head-down); (b) the Mk-4 Life Preserver (designed to be worn with the full pressure suit) provides 30 lbs. of *net* buoyancy with fair positioning qualities (This preserver is being used in some fighter squadrons in lieu of the regulation Mk-3C by pilots not wearing full pressure suits and weighted down with 30-35 lbs. of personal gear. This practice is obviously to be condemned.); (c) the Mk-2 (mae west) has only 20 lbs of net buoyancy and is obviously inadequate for our A-1, ASW and patrol aircrewmen carrying these weights of equipment. An additional 10 lbs of buoyancy is potentially available (in both Mk-2 and Mk-4 versions) via the oral inflation tube, but it is doubtful that this is a practical resource for a confused struggling half-drowned man or one who is injured or unconscious.

The Navy is currently taking development action on a high priority basis at the Aerospace Crew Equipment Laboratory to replace the Mk-2 Life Vest with a new generation preserver which provides 65 lbs. net flotation, plus head positioning insurance, without requiring reliance on an oral inflation tube backup. Results have been sufficiently encouraging to date such that the new item may be considered as an eventual replacement for all life preservers. In general, with awareness of all the hazard potentials discussed, continuous research and development effort is underway to reduce both bulk and weight of

personal equipment, increase standardization, and to more specifically define limitations in this area for command guidance and doctrine. The arrival of the end products in the Fleet will take time, however; hence the purpose of this article, which is to inform both the aircrewman and his commanding officer, in order that both may take appropriate measures in the interim based upon information now available.

Figure 3 illustrates the aircrewman configured with the new SV-2 survival vest (made of white material to stand out in the photograph—the issue item is basic green). This vest permits more optimal distribution of weight and bulk of basic equipment and "goodies" about the torso based upon ACEL studies. The new development life preserver will further improve the situation due to considerable reduction in bulk over the Mk-3C shown here.

Conclusions and Recommendations:

It is apparent that we must accept and live with a gross weight per individual aircrewman of currently designed *essential equipment alone* of about 30 lbs as a required minimum. The safe margin of extra weight allowance for extras or "goodies" is becoming alarmingly thin and in the case of flotation equipment has already ceased to exist for practical purposes. Furthermore, complete information is not yet available concerning the relationship of allowable weight and mass distribution to escape systems effects and function and only educated opinions presently can be used for guidance in these premises. We are confronted with a trade-off situation with respect to the "goodies." The following information should be borne in mind for purposes of policy and guidance on the subject:

a. Review of escape, evasion, and survival training practices and actual experiences reported by returned survivors from Southeast Asia accumulated to date indicates that, in most cases, location and rescue times are relatively short and with rare exceptions, have seldom extended beyond three days (barring detention by the enemy). Furthermore, the average aircrewman is *not* a survival expert with the background of an Eagle Scout or other intensive training in jungle survival.

b. Very little of even the basic essential items of equipment ever actually have been used by recovered survivors returned to date. On the other hand, impressive amounts of these equipment items have undoubtedly been acquired by the enemy via capture or abandonment by evading aircrewmen.

c. A thorough survey of the wide variety of "goodies" carried by individuals has indicated that a substantial portion of these extras are duplications of items already carried in the essential equipment inventory. Extra pistols, multiple bandoleers of ammunition, additional medicines, and various types of knives are a few common examples of such redundancy. The remainder of items which are truly individualized extras seldom weigh over one to two pounds, such as exotic hunting equipment (frog gigs, arrow heads, etc.), concentrated foods, or other items related to special skills of the individual.

The psychological support value of the extra items of equipment varies with the individual and must not be ignored; however, when confronted with a trade-off necessity, such as discussed in this article, it is obvious where the trimming will have to be attempted. It is recommended by the author that commanding officers and aircrewmen limit the allowable weight of "goodies" to a maximum of 5 lbs per man (and wherever possible, less) over and above the approximately 30 lbs of essential equipment inventory. The maximum allowed weight, in other words, should not exceed 35 lbs per individual. It is also suggested that those aircrewmen, so equipped, who are flying in ejection seat aircraft, secure their lap-belts and shoulder harnesses to the point of discomfort throughout flight in order to maintain optimum positioning in event of ejection.

You, too, can be a 97-pound heavyweight, so make every effort to "stay slim" both calorie and hardware-wise.

CAPT Roger G. Ireland, MC, USN, is Director of the Aerospace Crew Equipment Laboratory at the Naval Air Engineering Center, Philadelphia. He was senior medical officer aboard USS FORRESTAL (CVN-59) before reporting to ACEL as Deputy Director in 1964. He received his M.D. from the University of Colorado in 1948 and a master's degree in public health from Johns Hopkins University in 1960. He was designated a naval flight surgeon in 1952. Among his tours of duty are service as VMA-121 flight surgeon and later as MAG-12 senior medical officer in Korea. Dr. Ireland has been certified as a specialist in aviation medicine by the American Board of Preventive Medicine. He is also a graduate of the USAF course in space medicine, Cape Kennedy, Fla.

A Candid Appraisal of a Philosophical Approach to

Safety During Wartime

By CAPT J.J. Zarriello, Senior Medical Officer
1st Marine Air Wing, FMFPac

The statement is made in some quarters that the mission in wartime and safety are diametrically opposed. There is also an implied attitude that the accomplishment of a mission supersedes or takes priority over safety.

It is generally agreed that there are increased personal risks involved in flying an aircraft in wartime, but the purpose of aviation safety cannot be compromised. The goal of a pilot's mission is to make a delivery to a target. The safety goal is to accomplish the mission and return safely. These are parallel functions complementing each other in the accomplishment of a single task.

If a pilot crashes on takeoff because of improper preflight or pretakeoff checks (leave battens on or take off with folded wings), he may sustain critical injuries or even lose his life because of haste, neglect, oversight or carelessness. Late pullouts have been occurring frequently in this war zone, because of eagerness and excessive preoccupation with the mission (target fixation) with the resultant loss of life and aircraft. Wheels-up landings also have occurred recently.

These mishaps are fundamental and cardinal errors in an era of highly sophisticated men and machines. The professional pilot realizes his own importance as well as the importance of his mission. He guards against unprofessional habits and attitudes so as not to risk his life and aircraft recklessly due to non-hostile factors. A loss of a pilot or an aircraft represents a victory for the enemy, a defeat for safety and a great personal and economic loss for the squadron, group, wing and country.

Know your aircraft, know yourself. Know your NATOPS, safety procedures and equipment. Every mission during wartime is a risk, but don't gamble on safety and reduce your chances of survival. Be safety-conscious, so that you may return to fly another day. Think and think clearly—plan ahead and don't become another accident statistic.

after the fact analyses of some takeoff accidents.

EMOTIONS

A cavalier definition of mixed emotions is seeing your mother-in-law drive off of a cliff in your new Cadillac.

However, when a tire blows on takeoff it might be classed as that instantly required decision to fight it to a stop or try to get airborne. Such instantaneous decisions are not simple because the first indication of tire failure is usually through abnormal aircraft rolling behavior. It takes a real loud blowout to be heard above the engine. Secondly, the main wheels are not easy to see from the cockpit(s) and the nose wheel is nearly always hidden. No set pattern can be laid down because tire failures are caused by many things in different aircraft.

Recently an A-4 pilot detected a flat tire just before he reached the lineup position. This foolish, but lucky lad, pressed-on-regardless and made almost a normal blastoff, followed, some time later, by a safe arrested landing aboard a carrier. Subsequent verbal blowout from the squadron C.O. made him regret the action.

Another A-4 was making a normal takeoff with a good load of fuel and ordnance aboard. After 3500 ft of takeoff roll, the port main landing gear (MLG) tire blew causing the aircraft to swerve to the left. The pilot could not maintain directional control with the rudder even though his speed was in excess of 100 kts. Upon leaving the left side of the runway, the A-4 struck a runway marker just as the pilot lowered full flaps simultaneously with making the decision to horse the plane into the air.

After several bounces, the plane wallowed airborne but its staggering condition caused the pilot to consider a punch-out. A few seconds of timely indecision, fortunately, were a Godsend because the A-4 demonstrated it could make it even though it had no afterburner and in spite of the ordnance weight and drag. An uneventful and routine arrested landing was accomplished after jettisoning the external loads.

"Pow" went the left main tire of an F-4 just prior to liftoff. Everyone should be so lucky because the plane was airborne normally before the pilot could think of altering his plans. Like the A-4, this *Phantom II* was also carrying ordnance but the additional help of afterburner never let pilot apprehension develop. After jettisoning the ordnance, an arrested safe landing was routinely accomplished.

An F-8 blew a tire after rolling only about 200 ft on takeoff. Airspeed at the time was estimated at about 40 kts. One can only guess as to why the pilot continued (he did not survive). He might not have instantly realized the situation; he might have been anxious to get home (it was the beginning of his final leg returning from a cross-country) and felt he could horse it into the air; he may have felt he was beyond the point of a safe abort and a subsequent arrested landing would be safer . . . .

Like the A-4, the F-8 went off the left side of the runway and began to skip-along as if it might make it. Unlike the A-4, a formidable obstacle in the form of some GCA equipment loomed ahead. A pull on the *Crusader's* stick got it safely over the vehicle but the angle of attack was *too high for* the meager airspeed and it must be assumed that the pilot felt ejection was the only remaining course of action. Unfortunately, the plane had rolled 50 degrees to starboard and presented a condition beyond the parameter of the seat's ability.

Here we have four instances of tire failure on takeoff.

Now for some analyses. The first A-4 pilot was not forced to make that instantaneously required decision to go or no-go because he was aware of his tire failure before commencing takeoff. It would appear that he could have easily veered off the runway like the other A-4 and the F-8 and perhaps cause casualties.

Continued

More on the F-8

Next in line was the F-8. Since the pilot can not now defend his actions we must take liberties in our sympathetic diagnosis. He had no ordnance aboard like the second A-4 so danger from that was not present in case of a pile-up. Conversely, the absence of this ordnance would make a premature takeoff more feasible. It is possible that the pilot did not ascertain that a tire ever blew; however, it is reasonable to assume that he surely must have at least suspected the cause of the trouble when he could not keep the aircraft on the runway. In either case, his problem became compounded when the *Crusader* went off the side of the pavement as he approached liftoff speed. At this point, an aborted takeoff showed promise of a messy roll-up; and, with full fuel aboard, a very good chance of fire; and, poor survival percentage. The decision to continue was somewhat vindicated by the fact that he did get over the GCA van. Moreover, this, very likely would have been the object that an abort decision would have piled him into. If so, he sacrificed his life to save others???? Who really knows ????

The second A-4 pilot should consider himself lucky in view of what happened to the F-8 pilot. Although he was closer to takeoff speed, he had those touchy

Final resting place for blown tires.

bits of ordnance aboard to encourage him not to roll up in a fiery abort ball. On the other hand, that heavy ordnance load was an added hazard to an early liftoff, and he had no afterburner. Who is to say that this pilot and the F-8 pilot made the proper decisions? Both kept going, one made it, barely, and the other did not. Chances are that both pilots would have been injured if they had chopped the throttle after not being able to hold the aircraft on the runway and other casualties were good possibilities. The F-8 pilot surely would have survived if he had cut the power while still reasonably straight on the runway.

The F-4 Case

Back to the F-4 pilot, it is quite evident that he could not have stopped the airplane successfully, even if he had thought of it. There is no doubt that once close to takeoff speed, any thought of aborting involves mixed emotions. Moreover, an arrested landing virtually eliminates touchdown trouble, provided of course, that the wire is summarily caught. An *unarrested* landing with a blown tire becomes another story when touchdown speeds are near 100 kts or better like all of these subject airplanes. With wheels down, there is a good chance of blowing the other tires as well as undesirable gyrations on and off the runway. Under such conditions, some pilots have preferred to land wheels-up. Each such situation must be decided by competent authority at the scene, which in most cases, is the pilot.

Rules to Live By

Out of these four mentioned accidents every naval aviator ought to be able to arrive at some rules-of-thumb about when to continue the takeoff and when to abort. These rules will vary with the model aircraft and the loads aboard. A search through the NATOPS Manuals reveals the following pertinent quotes:

"F-8C Aircraft: Blown Tire:

Procedures

1. Abort, conditions permitting. If needed, use nose gear steering for maintaining directional control.

2. Perform short field arrestment. Refer to **Field Arrestments,** part 4, for short field arrestment techniques."

"F-4 Models: Blown Tires on Takeoff

A situation may occur when the main wheel tire(s) or nose wheel tire(s) blow on takeoff roll. If the nose wheel tires blow on takeoff, it is likely that one or both engines will receive FOD.

If Decision to Stop is Made

1. **Abort Takeoff**

Refer to Aborted Takeoff, this section.

2. **Leave Flaps in Position Set for Takeoff.**

Leave flaps in their takeoff position to prevent additional damage to wing flap seals in the event they have been damaged by pieces of broken tire.

If Takeoff is Continued

1. **Leave Landing Gear Down, and Flaps in Position Set for Takeoff.**

Leave the landing gear extended to preclude fouling the blown tire(s) in the wheel well(s). Leave flaps in their takeoff position to prevent additional damage to wing seals in the event they have been damaged by pieces of broken tire.

2. Monitor engine instruments.

If any abnormal indications, such as RPM, EGT, or engine vibrations are noted, it is possible that FOD is present.

3. Plan to make a short field arrested landing.

Refer to Short Field Arrestment section.

Aborted Takeoff

1. **Throttles—Idle** (left engine shutdown if required)
2. **Drag Chute—Deploy**
3. **Wheel Brakes—Apply**
4. Prepare for abort gear engagement, if required.

Abort Gear Engagement

This procedure involves only those steps necessary for actual engagement of the abort gear. It is assumed that those steps necessarily required (if available) for slowing the airplane prior to engagement have been accomplished; i.e., reduced thrust, drag chute, speed brakes, flaps and wheel brakes. Any time the airplane cannot be stopped safely on the runway, attempt to engage the abort gear, executing as many of the following steps as time will permit:

1. **Arresting Hook—Down**

Lower the tail hook at least 1000 ft ahead of the wire; 5 seconds are required for full extension (at 100 kts, you're going about 170 ft per second)

2. **Control Stick—Full Aft**

3. Aim for center of wire.

Steer to engage the wire near the center and at a 90 degree angle.

4. Release brakes 100 ft ahead of wire.

"Blown Tire on Takeoff A-4

If a tire blows on takeoff, the pilot must decide whether to abort or continue the takeoff. The following generalities are pertinent:

1. If a tire blows early in the takeoff roll before a moderate amount of rudder effectiveness is available (about 70 KIAS), the takeoff should be aborted.

2. At high gross weights where takeoff distance utilizes most of the runway available, increased drag of the blown tire may preclude successful takeoff. Abort the takeoff at any airspeed if arresting gear is available and if it is apparent that liftoff cannot be accomplished prior to reaching the end of the runway.

3. If a successful takeoff is made with a blown main or nose tire, after airborne, delay retraction of the landing gear until rotation has ceased. If possible, get a visual check of the condition of tire by another aircraft to determine whether or not retraction can be safely accomplished without having wheel hanging up in the wheel well. Usually, the tire will also be hot, and a minimum of three minutes should be allowed with the gear extended to permit the tire to cool.

4. The braking effectiveness of a blown tire is less than that of a tire in good condition. Consequently, to deliberately blow a good tire to balance another that has blown is not good procedure."

Where Do We Go from Here?

What causes these tire failures? There are still a lot of unknown causes, but most of them are known.

The first is termed normal *wear and tear* wherein the inspector thought it might make a few more landings. *Hard and abnormal landings* frequently cause internal damage not detectable by inspection. *Long taxi routes* on hot days—even if not downwind or downslope—often strain the side walls beyond recognizable limits. *Excessive braking* overheats wheels which in turn weakens tires to the bursting point and if so equipped, the fusible plugs will blow. Occasionally, aircraft tires emulate automobile tires by puncturing themselves on glass, sharp rocks or other such FOD. One tire manufacturer's monthly maintenance publication says more tires fail on takeoffs than on landings.

Naval Air Systems Command has issued a decision which will ultimately lead to considerable improvement of tire reliability. In essence, NavAirSysCom has initiated a program to discontinue the use of *recapped* high-speed tires for Naval aircraft.

. . . more tires fail on takeoffs than landings.

PROFESSIONAL COMPETENCE

"HASTE makes waste!"

The S-2F accident which occasioned this comment by the investigating flight surgeon was triggered by a maintenance error—failure to reinstall cotter pins after landing gear door actuating cylinder replacement.

"Equally worthy of mention," the flight surgeon wrote, "is the fact that the maintenance quality control inspection and subsequent preflight inspections by the line crews and pilots failed to disclose the fact that the cotter pins were missing." Nineteen flights later a nut backed off, a bolt fell out, and the end result was a Charlie damage wheels-up landing.

The flight surgeon's comments which follow are applicable to all of us in naval aviation:

"Hasty replacement of mechanical parts, hasty quality control inspections, uncertain record keeping, hasty line crew preflights, hasty pilot preflights—all are part of the vast aeromechanical wasteland wherein lurk the evils which daily destroy our aircraft and flying personnel. Foreign object damage, Murphy's Law, inadvertence, disinterest, even sabotage—such are the enemies with which we must wage continual battle as long as planes fly and men place their lives in the hands of those who make and maintain these aircraft.

"One AAR, one MOR, one APPROACH article, one Anymouse report, a set of wings, a crow—none of these or any other accomplishment will ever end our individual responsibility for searching out and eradicating incompetence. In spite of fatigue, long hours, short help, financial or personal prolems or any other distraction, all personnel related to aviation must continually be on the alert for the work of this ubiquitous enemy—incompetence.

"No matter what the circumstance, professionalism requires that competence shall never be compromised just as a surgeon, even if troubled or fatigued, must never compromise his attention and skill during an operation, jeopardizing the life of his patient.

"We must constantly attempt to develop such a sense of professional pride and responsibility in ourselves and everyone who maintains and mans our nation's aircraft if we are to reduce the incidence of mishaps resulting from thoughtless mistakes."

Nineteen flights later . . .

WIND CHIL

WIND VELOCITY Miles per hou						
45	35	25	A 20	15	10	5
TEMPERATURE Degrees Fahrenheit						
90°	89.5°	89°	88.5°	88°	88.7°	87.5°
82	81	80.5	80	79.5	78	76
72	71	69.5	68	67	65	60
63	61	59	57	55	52	44.5
51	49	47	45	42.5	38	28
41	39	36	B 34	30.5	25	11
30	28	25	23	18	11	—5
20	18	14	11	6	—2	—19
10	7.5	3	0	—6	—15	—35
0	—2.5	—8	—12	—18	—29	Below—40
—11	—14	—18	—23	—30	Below—40	
—21	—24	—30	—35	Below—40		
—32	—35	—40	—40			

Everybody knows it feels colder than the thermometer indicates when the wind blows and accelerates body heat loss but most of us don't realize how great the cooling effect of wind can be. Carrier-based or shore-based, naval aviation personnel have a wind chill problem which is intensified in winter months and in cold water operations. A wind-swept flight deck or airfield can be a mighty frigid environment and men working under these conditions should wear warm clothing and take precautions against frostbite.

In response to requests, we are reprinting here the Army wind chill chart, TB MED 81/AFP 160-5, 3 November 1954, from the January 1962 **APPROACH.***

For this table the unit of wind chill is defined as the amount of heat that would be lost in an hour from a square meter of exposed skin surface which has a normal temperature of 91.4°F. The figures in the table are approximate equivalents only and are not to be interpreted as

*(Change 3 which became available after January 1962, reworded the last sentence in Instruction 5.)

ILL CHART

per hour				
5	3	2	1	0
renheit				
87.5°	87°	86°	84.5°	83°
76	74	72.5	70	60
60	57	53.5	47.5	23
44.5	39	34.5	20	—11
28	18.5	11	0	—27
11	0	—9	—23.5	C —38
—5	—16.5	—40	Below —40	Below —40
—19	—40	Below —40		
—35	Below —40			
ow —40				

Wind Chill Chart Instructions

Instructions for use of the table (zero humidity factor):

1. First obtain the temperature and wind velocity forecast data.
2. Locate the number at the top corresponding to the expected wind speed (or the number closest to this).
3. From this point, follow across to the right on the same line until the last number is reached under the column marked zero (0) wind speed.
5. This is the equivalent temperature reading. Example: Weather information gives the expected temperature (at a given time, such as midnight) to be 35°F. and the expected wind speed (at the time, midnight) to be 20 mph. Locate the 20 mph (A) column at the top, follow down this column to the number nearest to 35°F. The nearest number is 34°F (B). From this point, move all the way to the right on the same line and find the last number which is -38°F (C). This means that with a temperature of 35°F. and a wind speed of 20 miles per hour, the rate of cooling of all exposed flesh is the same as at -38°F. with no wind.

absolute temperature equivalents. It should be further noted, Army Circular 40-27 states, that the term "wind chill" as used expresses only the **rate of cooling** which occurs in the **exposed or inadequately protected flesh.** Equivalent wind chill figures of +23°F., 0°F. or −40°F., even through they are below the freezing point of water (+32°F.), do not mean that all exposed flesh will freeze solid nor that even the surface will be frozen. Regardless of the wind speed, actual temperature readings above 32°F. will never result in freezing of exposed flesh. On the other hand, all unprotected flesh exposed to temperatures below +50°F. may result in cold injury of a type less severe than actual freezing of tissues and referred to as chilblains, trench foot, or immersion foot. The lower the temperature, the greater the wind velocity and the longer the exposure time the greater is the chance of cold injury. Many additional factors may contribute to or detract from this type of injury, e.g., physical activity, protective clothing, warming shelters, ground moisture, sunlight, moisture in clothing and extent of fatigue.

"Hold the phone, Charlie—I'm in the middle of a landing."

A MATTER OF WEIGHT

By John Christiansen, Jr.
P-3 Project Test Pilot

Zero Fuel Weight (ZFW) A nonlinear combination of inorganic materials and protoplasm arranged to defy gravity—less thrust liquids. Another way of defining it is to say ZFW is a number that everybody knows is terribly important but nobody—well, practically nobody—really understands.

Flight manuals briefly discuss maximum zero fuel weights for weapon loading purposes but rarely the how's and why's. If these remain unanswered, it's natural to presume that we are not pushing the numbers seriously. But actually, the ZFW limitations are as important as any other aircraft limitations. Respect for them prolongs structural integrity and insures a long, healthy service life for the airplane.

Abuse any structure with overloads and you are asking for trouble. Take a martini glass, for instance. It can maintain its structural integrity for a fantastic

number of years under normal loading (specified size olives, of course). But run it through a few load-unload cycles using lead shot and you can make a basket case out of it—a victim of overstress.

Function of Strength and Load

The maximum zero fuel weight for the P-3 is defined as the maximum weight to which it can be loaded with no usable fuel in any wing tank. This weight is dictated by wing strength and fuselage loading considerations. Both fuel and payload must be stowed and carried in accordance with the P-3 aircraft design criteria in order to maintain the complete flight envelope capabilities.

The intended service life of an airframe is derived by thorough design and stress analysis. This is then substantiated by means of a static and dynamic structural survey in which a programmed series of loads is imposed on the airframe over a period of time by hydraulically actuated jacks. Forces must be applied that simulate the maneuvers and loadings that the airplane will actually be subjected to in the missions for which it was designed. With the P-3, we went even further in this testing program than is done with most airplanes. For example, the usual procedure involves deciding how many landings the airplane will make during its intended service life, setting up the weights and hydraulic machinery to simulate a typical landing, applying stresses repeatedly to simulate the required number of landings and then rearranging everything to run it through, say, the takeoffs that would be contemplated.

P-3 Flights Were Simulated

With the P-3, we actually programmed the loadings for a series of flights—takeoff-climb-maneuver-land-taxi-takeoff-climb and so on. The first series of cyclic stresses simulated 7500 flight hours, and included 2500 takeoffs and landings. At the present time, a second series of tests is underway to simulate an additional 7500 hours. Final analysis of these tests will verify the P-3 predicated service life of 15,000 hours.

The importance of ZFW can easily be illustrated. Consider the wing lift on an airplane at a given gross weight and at a given load factor. The wing

"But you said don't put any in No. 5 Tank, sir."

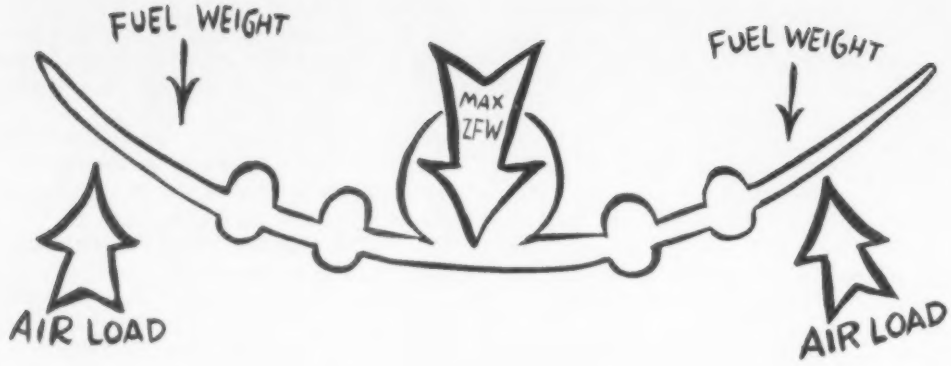


Figure 1

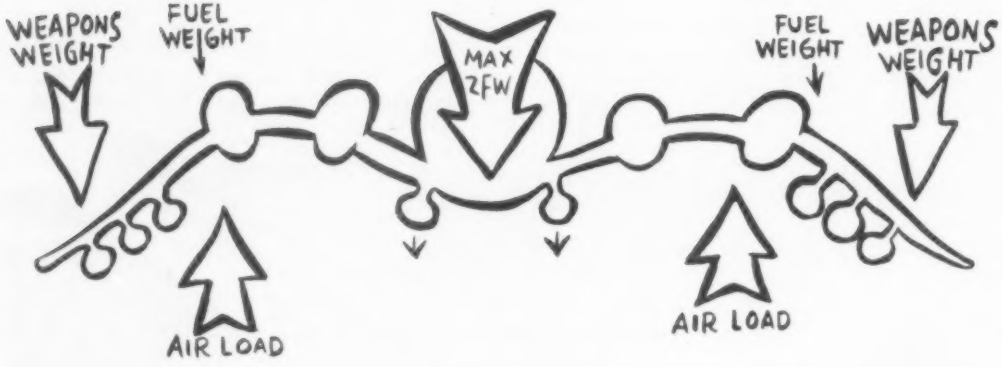


Figure 2

airload—total lifting force—is equal to the entire airplane weight and acts as a load applied to the wing. Increasing the gross weight by the addition of fuel (or increasing the load factor as in a turn) results in an increase in the airload required to lift the airplane. But if this added weight consists of fuel located in the wing, the fuel weight acts in a manner to relieve, or counter, the wing bending caused by the increased airloads. (Figure 1.) On the other hand, suppose the gross weight is increased the same as before, but by adding payload to the fuselage (Tank 5 Fuel, bomb-bay weapons, etc.). The airload, is increased just as before, but none of this added weight is located where it can counter or relieve the wing bending caused by the increased airloads. (Figure 2.)

How about the No. 5 fuel tank? Its integration with the fuselage would certainly lead you to believe that it should be part of the ZFW. Not always the case! The P-3 airframe was designed especially with the fuel system in mind. Fuel management simplicity coupled with the design wing strength allows for the normal use of No. 5 fuel without a ZFW

penalty. However, if you decide to leave the fuel in No. 5 tank, for some reason or other, it has to be considered as payload—and that's a lot of payload. I always consider No. 5 as an auxiliary fuel tank to be loaded only when the mission requires it. When you do load it, transfer its contents out to the wings as fast as you burn fuel—and keep those pumps on until the little green lights say, "that's all!"

The addition of weapons to the wing stations opposes wing bending due to airloads the same as the addition of fuel (Figure 2.).

The maximum zero fuel weight is generally a critical design condition for the wing. Exceeding the design ZFW will reduce the airframe capabilities and result in exceeding the airframe design loads—but most of the effect during normal flight activity is concentrated in the wings near the wing root area. So wing bending becomes a critical factor in the service life of the airframe because wing bending and fatigue go hand-in-hand.

There's nothing new in this vital relationship between loadings and fatigue. Consider the Camelus Dromedarious (camel). He can be expected to travel the sand dunes for five days with 400 to 600 pounds of payload, fueled to 15 gallons of water. Increase his payload to 800 pounds and you have reduced his stamina to only a three-day hike. Of course, there is one important difference between the camel and the airplane. Camels can snap back with renewed vigor—airframes cannot!

Designing an airframe for airloads is only part of the story. Moving the airplane from the ramp to the runway can sometimes turn out to be a thrilling ride in some of the backwoods areas. Wing fuel and airplane gross weight enter the picture here just as much as in flight. Taxi tests have been conducted on some of the worst undulating strips in these parts. The accumulation of data involved a considerable amount of cruising about under conditions somewhat like riding a Sherman tank over an obstacle

Camels can snap back.

course. The resulting information ranging from nose strut bottoming to wing bending frequencies, contributed significantly to the gross weight and fuel loading limitations set forth in the *manual.*

Adjust or Vary Taxi Speed

This experience with the worse kind of taxiing points up the importance, from the standpoint of airframe stress, of good pilotage on the ground. Taxiing, particularly with external stores or full wing tanks, can develop large dynamic loads in the wing. Taxi speeds should be adjusted or varied to minimize wing oscillation. On rough taxiways the location and depth of holes and bumps can be such that at certain speeds, the resulting wing motion matches the wing natural bending frequency. This condition, if allowed to continue very long, can severely damage the wing structure.

The pilot should be alert for any resonant condition that causes wing flexing to increase rather than dump out as it normally does. Even on smooth taxi strips this can occur if a series of raised joints of proper height and spacing provides bumps at intervals that match the wing's natural bending frequency. Even flat spots in the tires from prolonged parking can make the wings flop.

Poor taxi techniques have effects on the service life of the airplane just as detrimental as any other poor handling. Remember taxiing is as much a part of pilotage as flying—so don't drive it like a logging truck.

A final word about the "minimum fuel for flight" curves in the *manual.* You'll notice that they don't start at the maximum approved zero fuel weight (which by the way is now 71,584 lbs. for all P-3 aircraft without wing stores). They start a little higher, at a weight of 72,429 lbs.—845 lbs. more than the maximum ZFW. This particular number is the difference in capacities of the inboard tanks over the outboard tanks expressed in pounds. We plotted it this way so that you can fill the wing tanks, draw them down equally to the limit of the outboard tanks, and all the bookkeeping will come out nice and neat. Just remember, pay attention to these curves. They are just as important to the airframe structural capabilities as the red line on the airspeed indicator.

—Adapted from the Lockheed "Readyroom"

Thrilling the Folks

'Returning War Flyer Crashes on Family Farm'

Lt Joe Blow, Jr., who recently returned from Vietnam where he flew 201 combat missions, crashed to his death on his father's farm yesterday. The veteran aviator, according to his father, had telephoned him from Chicago that he was ferrying a plane to another base. His route took him over Podunk, so he would remain overnight at the municipal airport. The young hero said he would buzz the farm as a signal for the folks to drive over to the local airport to pick him up.

The folks were thrilled to see the sleek jet fighter screaming across the farm at treetop level. On the third pass, the plane struck a tree and crashed in the pasture just beyond the barn. By a miracle, none of Mr. Blow's prize cattle were consumed by the flaming holocaust that followed.

There is speculation that something must have gone wrong with the plane because an aviator of Lt. Blow's experience could not have been so careless. Funeral services will be conducted on Sunday.

Such headlines may make many of us reminisce. Almost every lad who graduates from flight school has had the yearn to imitate the birds as he grew up. Then, to reach that achievement is the epitome of success (for that endeavor). While attending the rigidly controlled military flying course, little time could be found to sneak off and flap those fledgling wings without the constant supervision. Nevertheless there is that stored-up desire to show the folks back home that junior is master of the iron bird.

Research through the years of aviation will dig up (literally) a fair percentage of those who did give the home town a thrill and a parade (funeral). We will not go back through the records to make a list of those who "bought the farm" because most of us remember some of those names. Moreover, some of us will also remember (with some fright) our own indiscretions of how we also, almost became a property owner of some bit of cubic footage.

The newspaper release at the beginning of this article is fictitious but we have all seen similar ones all too often in the daily press. It was kind of the "Daily Blat's" reporter to try to blame a faulty aircraft for this accident, but we all know differently. Moreover, the 899.9 hours that "combat veteran" aviator Joe Blow, Jr., had accumulated is still slightly short of the safe flyer's plateau.

These hometown airshows are known by many titles, such as buzzing the girl friend's house to give her that once-in-a-lifetime thrill; buzzing the summer beach resort because the ferris wheel is too tame; buzzing the boys' camp in the mountains where Joe Blow, Jr., used to work as a counselor . . . In this case Joe forgot about that often climbed nearby stuffed cloud . . . the lake resort is not a grand place for an aerial orgy because recently erected high tension lines do not show up well in the water's reflection.

So far, the many new and larger bridges have been avoided like the plague. Let's hope this is one sickness that continues to infect our ever growing ranks of flyers.

Now, besides joining the American Kamikaze Corps, there are some monetary matters involved. You just can hardly (or even softly) auger-in for less than one million dollars these days. If the airplane's price is under that, the cost of your training and burial will assist the inflation. Moreover, if you mess up some houses, the owners (if they live) may be able to deduct the loss from their income tax, but you will automatically be deducted. Also some grand law suits will evolve. It will not bother you afterwards, so *think* beforehand about the people you might take with you and all the trouble that will ensue.

Without trying to be personal, only recently a Vietnam veteran "pranged" (as the RAF chaps say —you see, this circus habit is not confined to Americans). Some people may be surprised to note that this latest folksy air show was done in a slow and presumed safe A-1 as opposed to a common supersonic jet.

Once a year we should all replay that "old broken record." There are old pilots and there are bold pilots, but there are no *old bold* pilots.

And The Band Played On...

After 30 minutes of flight in a UH-34D in connection with change of command ceremonies, the copilot complained of stack fumes and said he felt dizzy. The pilot suggested closing the hatch on the copilot's side and after a short while, the copilot resumed control of the aircraft. Some time later the copilot became erratic at the controls. When asked if he felt all right, he answered inaudibly and the pilot again took over. The copilot lost consciousness. The last thing he remembers is the helicopters in front "jumping up and down" and the band playing.

Five minutes passed before the helicopter was able to land. The copilot was semiconscious when the flight surgeon reached him. He complained of having smelled fumes. His face was flushed and his fingernails were cherry red. Given oxygen, he regained full consciousness and was taken to the dispensary. His only complaint at this time was a headache. A carbon monoxide blood test showed only 6% by volume.

The attending flight surgeon made a presumptive diagnosis of carbon monoxide poisoning: "While the level of carbon monoxide in the patient's blood was not enough to cause his trouble," he stated, "sufficient time elapsed between the onset of the symptoms and his examination to allow the carbon monoxide to dissolve. His history and symptomology and his appearance when I saw him first are enough to make a presumptive diagnosis of carbon monoxide intoxication very likely."

Characteristics of CO

Carbon monoxide is an odorless, tasteless, colorless and deadly poisonous gas. Its presence should be suspected whenever fumes suggestive of heater or exhaust sources are noted.

Even in minute concentrations, carbon monoxide is absorbed into the blood stream through the lungs at a high rate. Hemoglobin has an affinity for carbon monoxide 210 to 300 times its affinity for oxygen. A reduction in the concentration of oxygen in the air and an increase in the temperature or humidity speeds up the absorption process. When any of these changes take place or physical activity is increased, the toxic effects of carbon monoxide occur more rapidly.

In cases of acute carbon monoxide poisoning, unconsciousness often occurs before many symptoms can be recognized subjectively. According to the Navy's instruction on the subject (*BuWeps Instr 3750.4* of 7 April 1966), the first recognizable physiological symptom is a sensation of tightness across the forehead with possible slight headache. However, the instruction states, these sensations are not necessarily experienced until carbon monoxide blood saturation is at an unsafe level. Other symptoms include nausea, dizziness and dimming of vision.

Sources of Contamination

Carbon monoxide contaminants may enter the occupied compartments of all aircraft, particularly those of aircraft propelled by reciprocating engines. Deterioration of seals, opening of seams in structure and airframe modifications may result in increased carbon monoxide concentration in flight. All aircraft which have been modified, overhauled or stored for more than 30 days prior to delivery to service may be subject to excessive concentrations of carbon monoxide for these reasons.

Because of the flow pattern of air surrounding helicopters, particularly when hovering, the concentration of carbon monoxide may increase rapidly when the engine exhaust is into the wind. This can happen with cockpit windows either open or closed.

In all aircraft powered with reciprocating engines, concentrations of carbon monoxide may build up rapidly during taxi or when standing with engine idling and with engine exhaust to windward. The carbon monoxide may enter the cockpit areas through leaks caused by defective or torn boots on engine and flight control rods and cables, missing bolts in exhaust deflecting plates. and openings in firewalls, wing butts and cockpit bulkheads due to loose or missing inspection plates or inspection plate screws.

Aircraft of any type which are equipped with auxiliary power units are always suspect in regard to excessive concentrations of carbon monoxide. Special precautions are required in order to insure that the exhaust ducting is secure and that the fuel mixture ratio is adjusted correctly.

Aircraft equipped with missiles or guns are subject to large concentrations of carbon monoxide for varying periods, depending on the number of rounds fired or missiles released. Since the expanded products of combustion are usually projected ahead of the aircraft and then immediately injected into the air induction system, the concentration of carbon monoxide in the cockpit of such aircraft may momentarily exceed the allowable tolerance.

(Test procedures and allowable limits of carbon monoxide contaminants in naval aircraft outlined in the current issue of *Military Standard Mil-Std-800* are detailed in *BuWeps Instr 3750.4* of 7 April 66.)

Smoking CO Source

Another common source of carbon monoxide not usually considered is tobacco smoke. Heavy smokers may have 7% of their hemoglobin immobilized in this manner. This, in effect, means a heavy smoker starts his flight at an altitude of 5000 ft because the available oxygen carrying capacity of his blood is correspondingly lowered. Heavy smoking reduces vision in this manner, a fact that shows up particularly at night, because the eye is the body's greatest consumer of oxygen.

Above 10,000 ft, when demand oxygen is used, the dangers of carbon monoxide decrease with increasing altitude. As a higher percentage of oxygen is obtained from the demand system with increasing altitude, less of the atmospheric air and, consequently, less carbon monoxide is obtained. Above 30,000 ft where the demand system furnishes 100% oxygen, the action of carbon monoxide is completely prevented.

Although hemoglobin "takes up" carbon monoxide more readily than it does oxygen, the "rate of dissociation" is much slower. After absorption of moderate amounts of carbon monoxide, breathing pure air at sea level clears the blood of about one-half of the gas in one hour. Within eight hours elimination is practically complete. Increased amounts of oxygen accelerate the rate of excretion of carbon monoxide. When 100% oxygen is breathed following exposure to carbon monoxide, the elimination time is reduced to an hour or less.

Preventive Measures

What can pilots and flight crews do to protect themselves from the hazards of carbon monoxide? Here is what *BuWeps Instr 3750.4* says:

- Pay particular attention to the detection of odors of engine exhaust fumes and to the development of symptoms indicating carbon monoxide poisoning. If carbon monoxide contamination is suspected prior to take-off, the flight shall be discontinued until the source of contamination is determined and eliminated.
- Set the diluter demand valve at "100% oxygen" position, regardless of altitude whenever excessive carbon monoxide or other noxious or irritating gas is presented or suspected. Use undiluted oxygen until danger is past or flight is completed.
- Take precautions during ground operations to avoid contamination of the airplane either by its own exhaust or by the exhaust gasses of adjacent airplanes.
- In helicopters, avoid hovering with engine exhaust to windward.
- Ascertain that the preflight inspection chart shows that all fuselage openings including torpedo doors and depth bomb assembly doors are closed and properly secured.

Flight surgeons, the instruction states, shall make checks for carbon monoxide whenever its presence is suspected and make blood determinations on personnel involved. The aircraft shall be grounded until results of the tests are known and remedial measures are taken to correct any deficiencies existing in the suspected aircraft.

NOTES FROM YOUR FLIGHT SURGEON

Those Minor Illnesses

THE flu season is upon us, along with the common cold, digestive upsets and other minor illnesses—illnesses which do not seriously handicap individuals in other pursuits, but which may produce intolerable impairments in flying personnel. Inflammation accompanying a cold can cause extreme discomfort during altitude changes and painful, distracting injury to the ears and sinuses may result. Distention caused by gas in the stomach or intestines may give rise to symptoms varying in intensity from mild discomfort to incapacitating pain.

There should be a general awareness of the fact that flying renders seemingly minor conditions, described as feeling "poorly," "not up to par," "bushed," "under the weather," and the like, potentially most hazardous.

Flights should not be undertaken when there is any question regarding the fitness of the individual pilot or crewman.

Let's fly it safe, huh?

—Flight Surgeon's Memorandum
NAS Seattle

Wing Walker Injured

THOUGHTLESSNESS and poor supervision resulted in serious injury to a wing walker while a helicopter was being towed to the wash rack.

Both port and starboard wing walkers were riding the towbars. In an area where the helicopter's rotor moved close to a parked aircraft, the port wing walker got down to insure safe clearance. Attempting to reboard the moving helicopter by way of the port arm of the tow bar, he slipped and lost his balance. He fell to the ground directly in front of the helicopter's port main landing wheel. Both the tractor driver and helicopter brake rider immediately applied their brakes. By this time, however, the helicopter's wheel had rolled on top of the wing walker. The tractor driver instantly backed off but in the intervening seconds the wing walker had sustained serious injury.

Poor procedure was the primary cause factor here. The wing walker attempted to board a moving aircraft and made it worse by boarding from a position which would, if he fell, put him directly in the path of the aircraft wheel. The tow bar upon which he jumped is normally unstable, the accident report states.

The secondary cause factor was lack of proper supervision by both the tractor driver in charge and a second class petty officer who was a passenger in the tractor. Both men could have prevented the wing walkers from riding the helicopter's tow bar or landing gear struts.

O_2 Caused Ear Pain

FLYERS who have been breathing pure oxygen at high altitude for a considerable period sometimes develop an ear ache two to six or more hours after landing, even though their ears cleared during descent.

For instance, ear pain may awaken them after they have gone to bed, or be present on awakening in the morning. This occurrence is due to the fact that after a flight on 100% oxygen, the gas in the middle ear has a very high oxygen content rather than the normal 21%. Oxygen is normally absorbed into the middle ear tissues at a slow rate. The usual periodic swallowing allows entry of sufficient new air to maintain the proper pressure within the middle ear cavity. When the oxygen content in the cavity is very high, however, absorption is more rapid. Therefore, the normal rate of ventilation is not sufficient to maintain the 14.7 psi pressure required for equilibrium, and a reduced pressure or partial vacuum develops within the middle ear.

Prevention of this condition is simple, but too often overlooked. For one or more hours after landing, flyers should perform the "Valsalva maneuver" every few minutes. (This is the same action of closing the mouth, holding the nose, and blowing gently which is recommended for opening the Eustachian tube valves during descent.) Frequent Valsava maneuvers insure maintenance of proper pressure in the middle ear cavity despite the rapidity of oxygen absorption. Equally important—with each Valsalva maneuver on the ground a slightly increased pressure is built up in the middle ear and the excess gas is expelled through the Eustachian tube. In effect, then, you are flushing the middle ear cavity with air containing 78% nitrogen. The proper gaseous concentration is soon reestablished and your normal rate of swallowing is again adequate to maintain the pressure as oxygen is absorbed. Because of the slowed rate of swallowing during sleep, this preventive procedure is particularly important if you are going to bed shortly after landing.

—USAF Pamphlet 160-10-3

Gouge

WASH, wash and wash with water, water and *more* water! This is the emergency treatment to be utilized *immediately* in any case when a person gets any foreign liquid in an eye—liquid such as fuel, cleaning solution, acid, etc. Some chemicals are so damaging that an eye can be lost in the time required to get from operational areas to medical. Therefore, first aid must be given at once and must consist of rinsing out the involved eye with copious quantities of water for a period of perhaps 5 minutes (by a watch). Then the person can be taken to medical for further evaluation and treatment by the medical officer.

Under, Not Over

AN RF-4-B pilot's helmet was pulled from his head during personnel parachute deployment following ejection. The over-the-shoulder oxygen-communications integrated hose leading from the mask was routed *over* vice *under* the pilot's shoulder harness to the parachute. Presumably what happened on chute deployment was that as the risers extended, they pulled on the hose and eventually pulled the helmet from the pilot's head. (The pilot's hard hat, which was borrowed, was very loose.)

The over-the-shoulder oxygen-communications integrated hose must be routed under the parachute riser and shoulder harness (reference *Air Crew System Change 62* of December 1965 and *Interim Change 11* and *Change 33* to the RF-4B and F-4B NATOPS *Flight Manuals* respectively).

No Inner Liner

A survivor of an S-2E crash during night ASW operations hung on to the side of an injured survivor's raft 80 minutes before being rescued. Water temperature was 62° F. and air temperature, 42°. Although he was wearing an anti-exposure suit, after rescue he stated that he thought that another hour in the water would have been fatal.

The survivor's troubles were due to two factors: 1) He was wearing thermal underwear instead of the suit inner liner and 2) He failed to zip up the neck of the suit until after he had taken on a large amount of icy water.

"The amount of water taken into the suit before the neck was closed plus the inadequate protection of the cold-weather underwear vice the suit inner liner combined to form a near disastrous combination," he stated. "I don't feel I could have survived in that temperature water until sunrise in that configuration. If exposed to the same situation again, I would definitely be wearing the anti-exposure suit liner!"

Excess Baggage

IN an ejection from an F-4B, an RIO received bruises on the calves of both legs. This, the investigating flight surgeon thought, was probably the result of his legs being snapped back to the seat by the leg restraints. *The RIO was carrying a half-full parachute bag between his legs which probably prevented leg retraction until the seat was partially up the rails.*

THE RIGHT FASTENERS ARE A FLYER'S

Threaded fasteners—bolts, screws and nuts—hold together much that is vital in a naval aircraft, its launch apparatus and related support equipment.

Bolts and such are used—rather than, say, rivets or welded joints in many cases—for a variety of reasons, not the least of which is the subsequent need to disassemble, for inspection, servicing or overhaul and repair of engine and airframe.

A seemingly simple mechanical device—one-piece, no moving parts—the precision, high-strength bolt and its mating nut are nonetheless highly engineered components designed to stand up to extreme forces, constant vibration, environmental factors such as high and low temperature and the wear-and-tear of repeated tightening.

Since they are precision parts, and not just inconsequential hardware, aircraft fasteners are designed with care, made with care, specified and selected with care. Therefore aircraft fasteners should be installed and tightened with care, and *carefully replaced* (when necessary) with the identical part or exact equivalent as specified by the parts list.

Most critical naval aircraft bolts and screws today have threads that have been rolled.

The actual thread form, or contour, however, may stem from any one of three military specifications—Mil-S-7742, Mil-B-7838 and Mil-S-8879. (See illustration A) The older Mil-S-7742 is essentially a "cut thread" standard, as we shall see. The latter two—superior structurally—represent modern and more reliable forms of the age of precision thread rolling. A seemingly minor variation among the three—in the shape of the root at the bottom of the thread form—is the reason for the tremendous range in their performance and reliability.

Years ago, when virtually all screw threads were cut with a single-point tool on an engine lathe, the shape of the thread was a sharply pointed 60-degree V notch. It was, that is, just as long as the tool was freshly ground. But as the point of the tool inevitably wore, the root or bottom of the resulting screw thread rose higher and higher and became more ragged in shape, until the condition got so bad that the threaded part would no longer fit the Go gage. (Nobody worried much about fatigue strength or dynamic reliability in those days, so another important side-effect went unobserved.)

Out of this worn tool phenomenon, came part of the specification for the Unified screw thread standard that governs most of the commercial and industrial fasteners made in recent years. In this Mil-S-7742 standard thread form, sometimes referred to as the truncated thread form, the critical root contour is allowed to vary with tool wear between two limits, without requirements for any specific shape or condition of the root surface. The Mil-S-7742 thus is a standard from the cutting or grinding tool era, though it is presently being thread-rolled onto a large number of screw threads.

Its unradiused and generally uncontrolled shape in the root area makes it structurally inferior to a radiused root thread.

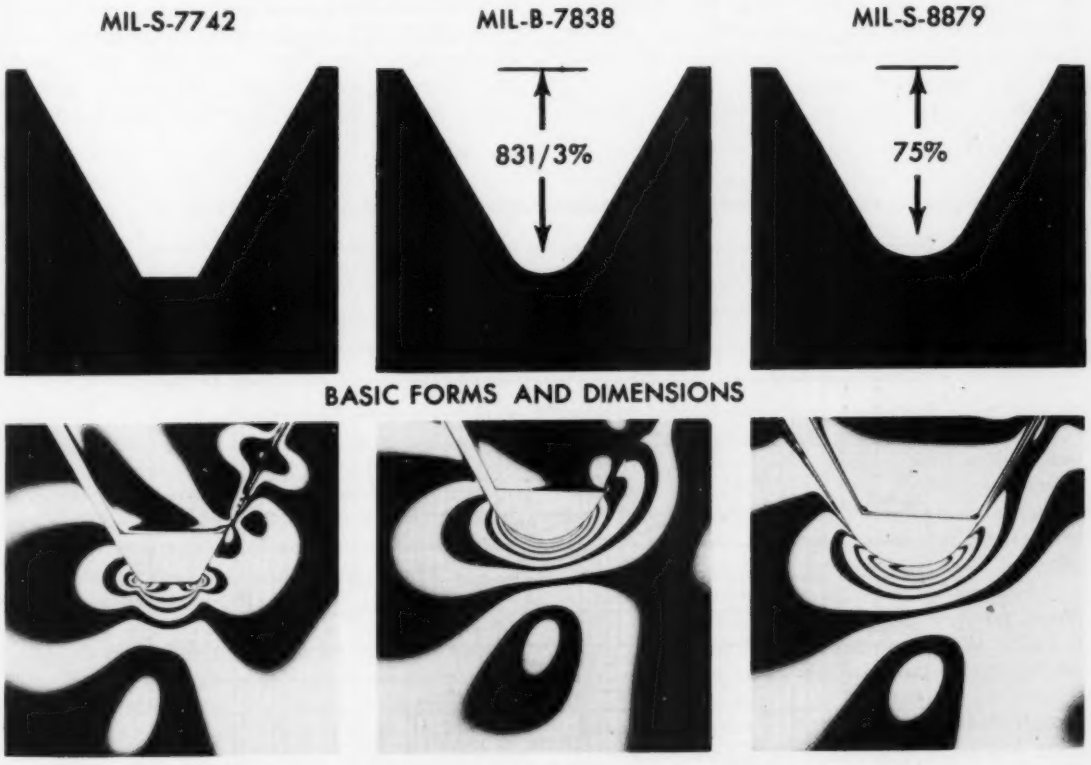
Historically, the structural inadequacy of this thread form was pointed up by the demands and rapid advances of the aviation industry. To fly faster and farther, engineers had to design more efficiently to smaller factors of safety.

Around World War II, it was observed that threaded parts in a joint failed much sooner and under smaller loads than would be expected on the basis of their proven static tensile strength. This was diagnosed as metal fatigue. Under repeated, cyclic stressing the metal was "tiring" and finally fracturing. The actual size of the load that eventually caused

S BEST FRIEND

By Edward F. Gowen, Sr.
Product Line Manager, Aerospace Bolts
Standard Pressed Steel Co.
Jenkintown, Pa.

COMPARISON OF THREE BASIC THREAD ROOT FORMS



Flat thread root form with sharp corners develops high stress concentrations.

With radiused thread root stresses are more evenly distributed.

With still larger radius this thread root distributes stresses increasing fatigue life.

Note the decrease in stress concentration from MIL-S-7742 to MIL-S-8879.

Illustration A

Continued

failure might be only a small fraction of the load that the same bolt could withstand once, or even a hundred times—but perhaps not a thousand times.

The likelihood of fatigue-type failures was proportional to the severity of any nicks, notches or other sharp discontinuities in the structural part. The sharper the notch, the greater the stress concentration at that point, and the more likely and quicker the disaster. And a bolt, of course, is loaded with "notches" under the head and in the threads.

The solution—one known to the art of engineering for some time—was to reduce the notch severity by smoothly and generously radiusing the sharp corners and thread roots. An early result was the first radiused root thread form—that of Mil-B-7838. It has a smooth, radiused root contour blending into the flanks of the thread in such a way as to permit gaging with the existing Go gages developed for use with the Mil-S-7742 cut thread form. The Mil-B-7838 thread in fact has the largest radius that can be fitted into a 60-degree thread form without interfering with these inspection gages.

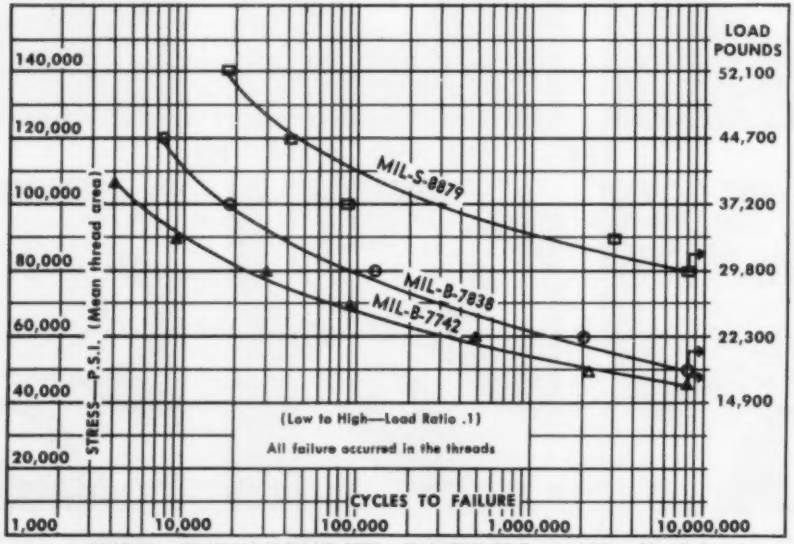
With the naked eye, you can scarcely see the difference between Mil-S-7742 and Mil-B-7838 thread forms. But the difference in performance can be enormous (see illustration B). In critical, highly stressed joints, it could literally be the difference between failure in a few hours and continued performance for years. The radiused root was truly one of those "tremendous trifles" of WW II.

Ever since, an increasing number of aircraft fasteners have been made with the radiused thread root of Mil-B-7838.

A logical further step was taken in 1960 with the adoption of a still large-radiused root thread form—that defined by Mil-S-8879. This is sometimes referred to as the 75-percent thread, since its root radius is the largest that can be fitted in at a depth of 75 percent of full thread height. This larger radius gives significantly better performance and longer bolt life under fatigue loads than do Mil-B-7838 threads. *It is now mandatory on all new Navy aircraft bolting.*

The Mil-S-8879 thread will not fit the conventional Go-ring-gage. Gages used with 8879 bolt threads must have the minor diameter (hole in the middle) drilled out to a depth of 75 percent. This is a simple

EFFECT OF ROOT RADIUS ON FATIGUE, STRESS RUPTURE AND TENSILE STRENGTHS



TENSION—TENSION FATIGUE TEST ¾-16EWB-22 External Wrenching Bolt

Illustration B

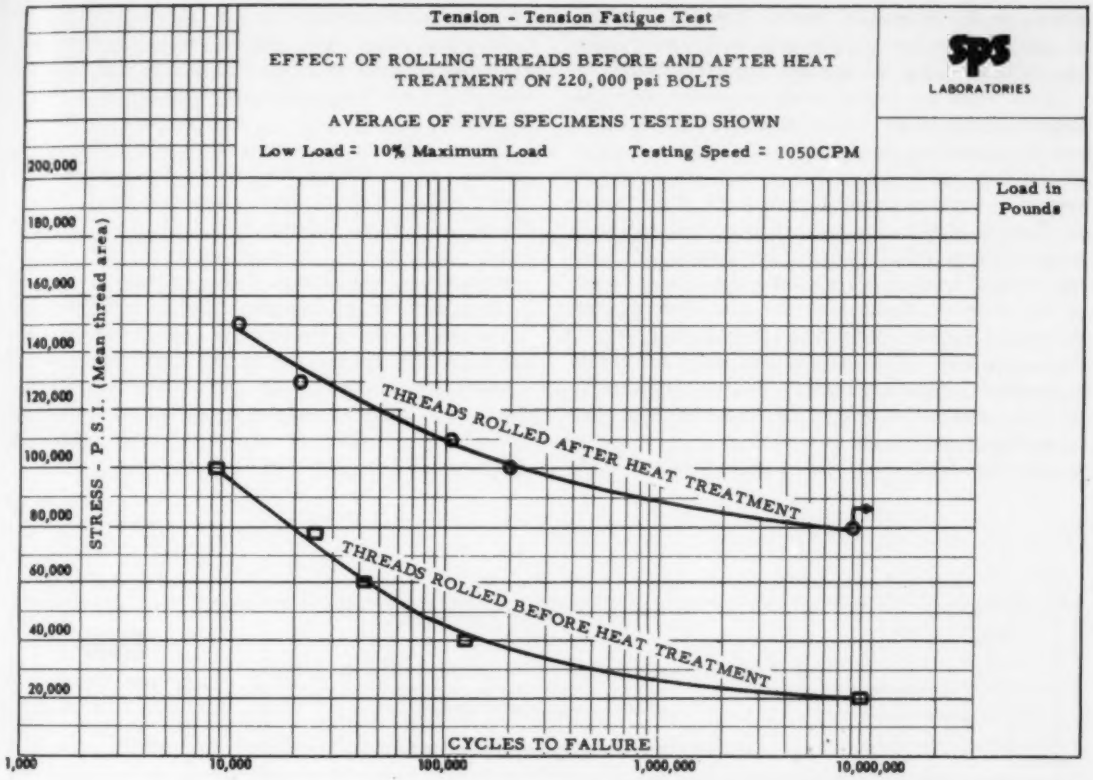


Illustration C

matter of using a larger drill size to begin with in the production of the gage. The large-radius 8879 thread, however, does mate interchangeably with virtually any standard nut or tapped hole. For the sake of manufacturing economy, internal threads are hardly ever tapped to a depth beyond 70 percent. Most nuts and tapped threads, in fact, have a depth of only 60 to 65 percent.

The Mil-S-8879 thread form, as a result, has virtually all the advantages, with scarcely a disadvantage. It may even prove less costly to manufacture in commercial volumes. The difference in root radius between Mil-S-8879 and Mil-B-7838 is microscopic, but here again the difference in performance is great, as can be seen from the accompanying plot of cycles to failure. (Illustration B). Since it is completely interchangeable for all practical purposes, it eventually may be as common and universal in industry as was the truncated-root Mil-S-7742.

Even now further advances in the design of the root of aircraft threads is underway. A very-large-radius thread of 55 percent depth has been developed for highly notch sensitive products such as beryllium bolts for space satellites and 300,000 psi-tensile-strength superbolts now going into the most advanced military aircraft. This even more fatigue-resistant root form is essential for the structural integrity of these highly notch-sensitive fastener materials.

This relatively shallow thread form requires special mating nuts. But despite the shallowness of thread, it retains virtually all of the stripping strength of the deeper thread forms.

Though not quite as shallow as a lamp-bulb thread, the 55-percent-depth thread, as well as its now more commonplace predecessors, does suggest a trend in that direction.

Bolts and Screws

To be of any use as a practical fastener our theoretical thread must take the form of a bolt or screw and a mating nut or tapped hole. Bolts and

screws are the externally (male) threaded members of the fastener family. The nuts and tapped holes have what is called the internal (female) thread.

Shear bolts act pretty much as hardened, close-tolerance cylindrical pins with a head on one end and threads on the other principally to keep them in place. They must sustain forces that act mostly to cut across (or shear through) the shank of the fastener. Tension bolts and screws are designed to clamp parts together with relatively high forces and transmit external loads that work along the axis or length of the fastener. Because of the concentrated loads that must be transmitted through its head and threads, the tension bolt is a mechanically complex and highly engineered component. The pin-like shear fastener in this sense might be said to be somewhat less complex (though this would be a difficult thing to prove to any pilot who lost one, for example, from his flight or fuel control systems.)

In either case, both tension or shear bolts are tightened to develop a clamping force—and it's this clamping force that is the principal job of a screw thread.

Tension bolts in particular must clamp things together, and the tighter the better: (1) because tight joints mean much stronger joints with far less likelihood of fatigue failures, and (2) because tight joints mean no-leak connections and rigid, sturdy structure with a minimum of slop or play.

Structural tension and shear bolts in airframes, engines and auxiliary systems, are critical components. Each one has been designed and engineered for its specific job. There is really very little room, if any, for second guessing or playing of hunches, when it comes to selecting or replacing these precision fasteners.

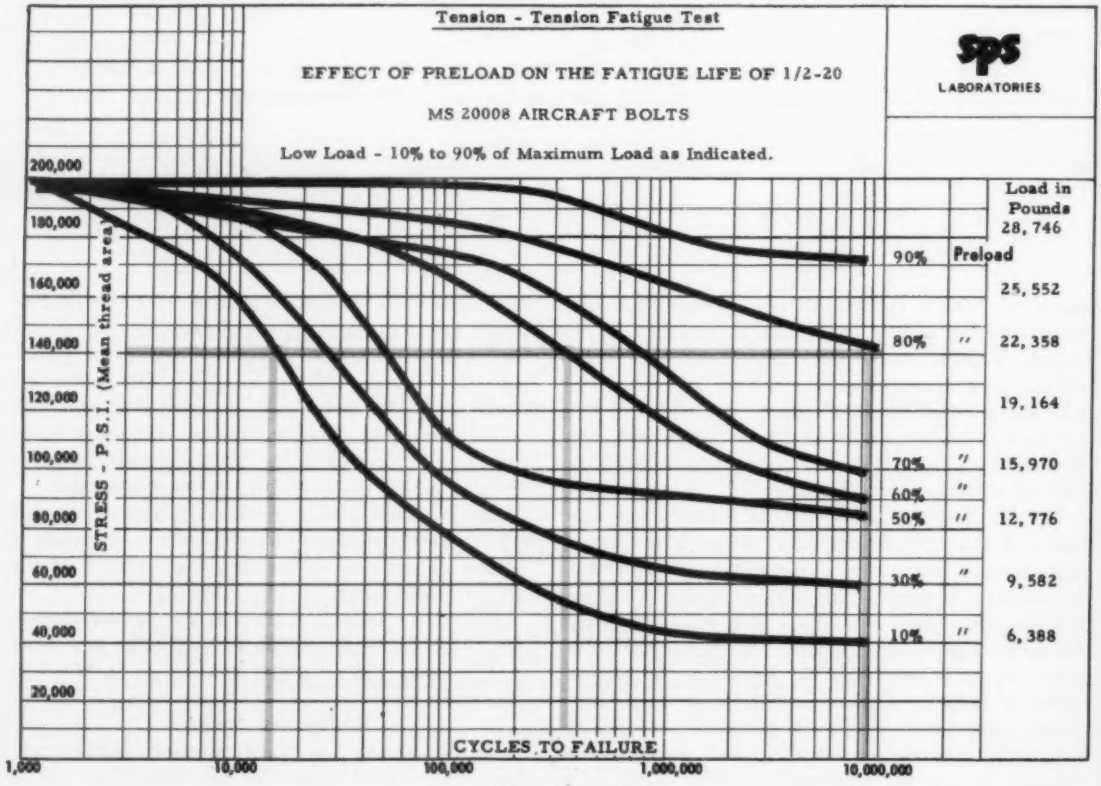


Illustration D

Subtle variations, for the most part invisible to the naked eye, make the difference between bolt and "bust," between success and failure of mission, and sometimes between life and death.

For example, one bolt may have threads rolled after hardening by heat treatment of the fastener blank, and the other seemingly identical part may have had its threads rolled before heat treatment. The former is much, much stronger in fatigue and will have a much longer cycle life. The less fatigue-resistant bolt might not make it to that next maintenance overhaul. The great difference in bolt properties is plotted in the chart on Page 39. (Illustration C)

Let's just take a look at some more of the many ways in which great differences in performance can result from seemingly minor differences in bolt specifications:

- *Radiused Threads*—The difference might be as much as a ratio of 1000 to 1 or more in bolt life (see chart), though this will vary widely with type of bolt and application and severity of loading. (Illustration B).
- *Rolled Threads*—This chart shows greater range in fatigue performance between threads rolled before and after heat treatment. (C)
- *Strength Level*—Both 180,000 psi and 300,000 psi 12-point external wrenching bolts may look the same. You might have to break them in a tensile tester to tell the difference. But there is a big difference.
- *Materials*—Similar looking bolts might be made of alloy steel, stainless and titanium. There's not only a great difference in their relative corrosion resistance and anti-seize properties, but the wrong choice might bring together in the joint two incompatible metals with eventual failure resulting from the ensuing

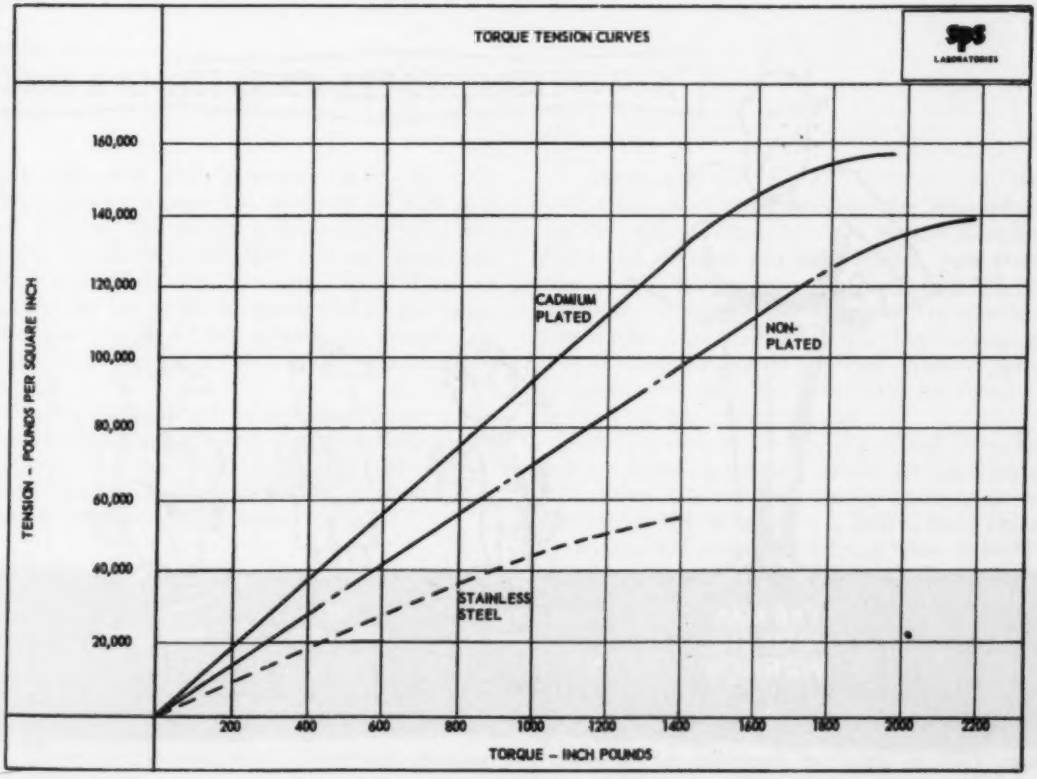


Illustration E

galvanic corrosion that is set up.

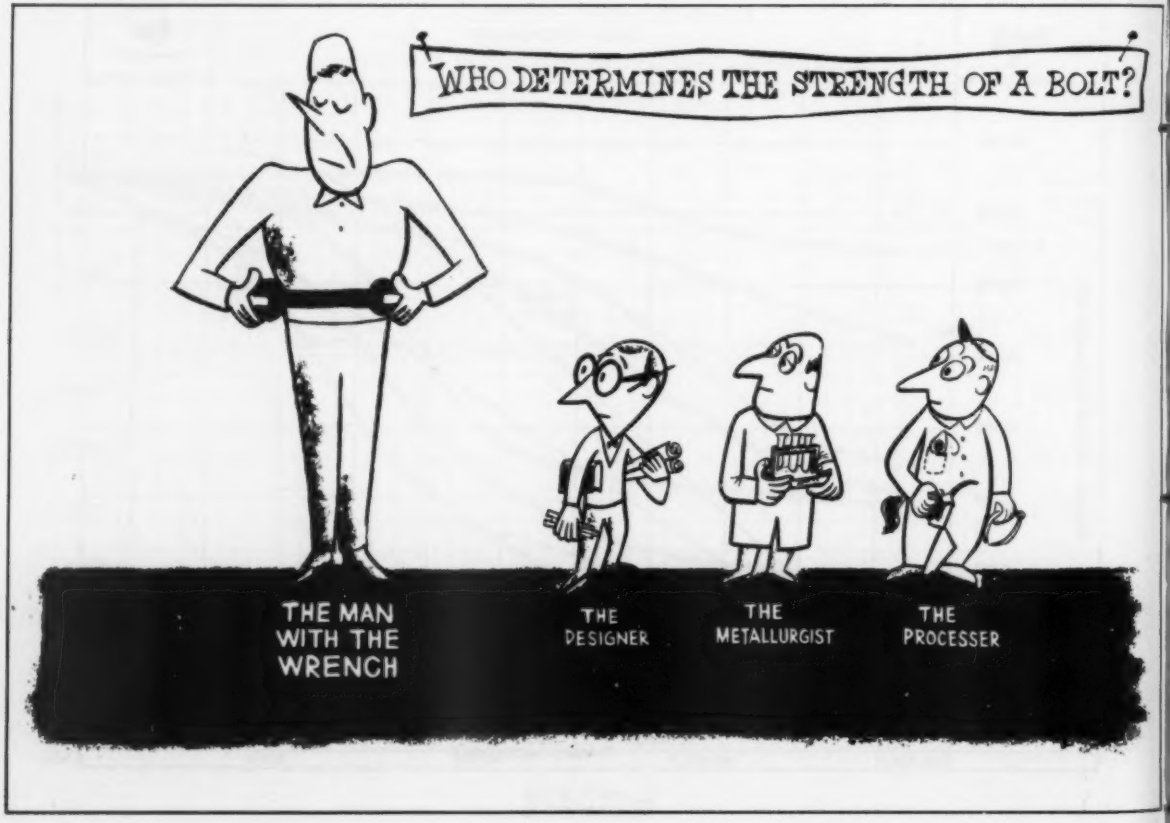
• *Temperature rating*—A bolt made of H-11 material is a great product—up to 900°F or so. The identical looking fastener made of A-286 alloy would be a better bet for that 1200° hot-spot.

• *Plating*—That bolt that looks just like the elevated temperature bolt, and fits just like it in the same hole, isn't going to do if the plating is plain cadmium, which starts to melt above 400°F. When used beyond 400°, not only may corrosion resistance be lost, but the presence of liquid cadmium may induce prompt failure due to something called stress-alloy cracking. Better stick to the parts list which calls for the same bolt with a diffused nickel-cadmium plate which is good at higher temperatures.

• *Tightening*—The chart shows the difference in bolt life between tight and not-so-tight tightening. Better use the torque wrench as prescribed. (Illustration D)

• *Lubricant*—The presence or absence of plating or lubricating oil, and the kind used, may make a difference of 50 percent or more in the amount of actual preload induced in a bolt for a given amount of applied tightening torque. Without lubricant, or with poor lubricant, more of the applied tightening goes into overcoming friction; less of it gets through to tighten the bolt. In line with what has been said above about tight tightening, this can mean trouble.

Are these subtle differences for the most part? Sure. And these are mistakes that can be easy to make. Better stick right down the line to the parts lists. When it comes to critical bolting, haphazard replacement practice is surefire mechanical hara-kiri.



Each 3-M document is intended to tell a story, the story determines the needed parts, when and how much of a budget is needed. If documents tell the wrong story, effort and money will be wasted.

INPUT ACCURACY

...the Heart of 3-M

The cost of a single aircraft is many times the amount of money that most of us will earn in a lifetime. The cost of a single high value item for an aircraft or missile may represent more than we as individuals earn in several years. When we consider the cost to the government of all the equipment used by all of the services, it staggers the imagination. Remember, we are the ones who pay the bills.

To get a dollar's worth of defense for every dollar spent, we in aircraft maintenance must make use of a system. We have such a system: 3-M—(Maintenance and Material Management) formulated to monitor and control maintenance dollars.

Basic Questions

To make this system work, and provide the needed data, we ask certain questions of the maintenance technician:

- Why was the work necessary? (How Mal code)
- What work was done? (Action taken code)
- How long did it take? (Total labor hours)
- Where was the work done? (Basic and assisting work centers
- What Technical Directive was accomplished?
- What parts were used?

The simplest means of reporting this information is the Maintenance Data Collection System. Completed forms are processed through electronic data processing machines and management receives the information in the form of tabulated reports. The worldwide data is edited, the information from like weapons systems is compared and the technical directives update programs evaluated. Any errors that are found are reported to the originating unit.

Decisions, such as how many men will be authorized to maintain a weapons system, are based on the information gathered from similar maintenance organizations. This information is used to apply against the mission and programmed flying hours to build a Unit Manning Document. However, the manpower resources allocated to a using command do not become the command's permanent property. Authorizations are provided to accomplish specific tasks and/or missions. The authorizations are always subject to withdrawal and re-allocation to provide for workload changes or to accomplish higher priority work.

Missions are expressed in terms of work capabilities. They must then be converted into cost of facilities and manpower requirements to enable us to

Data generated by the system is no less important than ordnance expended. . .

allocate both the required number of people and the necessary funds.

Operating Costs

All of this leads back to the cost of operating, which in maintenance must be continually evaluated. Our resources, for example, are spread thin across the world while we train and stand alert at the same time. As we convert to more modern weapon systems, the work we must do must be documented so that manpower requirements, trends, and failure rates can be established and validated.

Of equal importance is the data from older weapon systems; systems that have been modified and updated many times and are now subject to failure in different time or service schedules. When this information has been assembled and studied, we can increase or decrease inspection cycles, determine needs, and improve manpower utilization by directing our efforts to clearly defined trouble areas. All of our efforts reach their goal when the pilot is launched upon a safe, successful mission.

Operations personnel also must be thoroughly familiar with all aspects of the maintenance management system. As an illustration, the squadron commander and his operations officer should know:

(1) how many men are assigned to the maintenance unit and what are their skill levels;

(2) how many man-hours are expended to support one flying hour and one sortie; and

(3) what are the maintenance problems, maintenance requirements, fleet time, and the status of Technical Directives and compliance modifications.

The 3-M system is not just a maintenance management system. It is a management tool to aid in affixing a price tag to our mission.

The paper generated by the system is no less important than ordnance expended against an enemy. Each maintenance document is intended to tell a story, and this story determines the needed parts and when and how much of a budget will be required. If documents tell the wrong story, our efforts and our money will be wasted. Unwittingly, we will have accomplished what an enemy tries to do; waste our resources and wear us down until the struggle can no longer be maintained. Our data must be timely and correct. Above all we must be able to use it.

—Adapted from "Aerospace Maintenance Safety."

Progress Report

3-M Is Here

We have reached the point where the 3-M (Aviation) system has been implemented in all CVAs/CVSs, aircraft squadrons and all stations.—*ComNavAirLant*

Progress made in the 20 months since the first fleet implementation:

a. The implementation rate is right on schedule with most activities currently reporting under the program. Based upon this rate, we should be fully implemented by 1 Jan 1967.

b. The Aviation 3-M Manual has been continually updated, based upon fleet inputs. The fact that the manual has remained current and responsive to the needs of the fleet, has been invaluable in maintaining the vigor of the system.

c. Based upon the growth and capacity of the data bank at the Maintenance Support Office, it has been possible to initiate the development of a new family of management reports. These reports will enable a more searching look at the reasons for nonreadiness and enable corrective actions to be based on facts rather than intuition.

d. Progress is being made in the development of additional uses for Aviation 3-M data. NORSAIR reporting and Depot Level Reporting are but two examples of the efforts currently under way.

However, the work has just begun. The job of putting to work the revised maintenance and material procedures and using the wealth of data being processed and accumulated is a managerial challenge which must not be slighted. It is not enough to merely have the tools available with which to manage our assets. These tools must be applied with human intelligence to accomplish the goal of the 3-M system, increased material readiness.

The system was not designed to be self-supporting nor all inclusive in accomplishing the monumental task of improving over-all management of resources within the Navy. To reap the benefits of the 3-M system, all levels of management must put to intelligent use the data being accumulated and reported. We have seen evidence of improved manpower utilization, improved support, and consequently, improved material readiness within our units during the short time we have had the benefit of this management information system to assist and guide our efforts.

The monthly summary of 3-M (Aviation) data prepared by individual units is a most useful and informative document. It has paved the way toward an initial appreciation of the primary value of the data through critical self-analysis at the local level.

Don't Forget Those URs

Although the vast bulk of maintenance and material failure data will be collected, sorted and distributed by the 3-M System, the Unsatisfactory Material/Condition Report (UR), NavWeps Form 13070/5 still represents your best direct narrative link with the man at the drawing board, the Navy contractor quality control inspector, or the logistic specialist concerned. The UR format is mandatory for flight safety items but can also be used to report improper maintenance procedures, publication errors, suspected design discrepancies and faulty components received from supply. This form can and should be used to convey amplifying narrative information which could expedite the processing and analysis of major maintenance and operational discrepancy reports. (See Chapter VII, Page 23, 3-M Manual.)

How Mal? What Action Taken?

Incorrect voltage on the Main Landing Gear and Wheel Assembly corrected by calibration??? Don't laugh. If attention is not given to the use of codes, such errors in reporting do occur. It is not enough merely to insure that codes fill all the proper blocks—they must be appropriate codes. It is not enough to have a low error rate in the source documents sent to data processing—the codes must reflect actual descriptions of the information being reported. The error editing program checks for the presence and in some cases the data characteristics of a code, but not the information reflected by the code.

It is essential that all personnel concerned with the documentation of data insure, through personal review, that the data collected is accurate. Don't allow guesswork and inattention to invalidate your contribution to understanding a problem. Without valid input we can't expect valid products, and ultimately valid analysis.

Beware the cold punch of winter!

Letters

Wind Chill Chart

Brooklyn, N. Y.—With the coming of the winter months, one of the primary concerns to naval aviation personnel deals with wind chill factors. The effects of wind and low temperatures on exposed skin are of interest to flight personnel and also ground personnel. It is recommended that APPROACH feature an article concerning this subject with the addition of a chart which may be removed and posted in ready rooms, weather offices, etc. Such a chart would provide an easy and quick reference for interested parties to determine the wind chill factor from the existing wind and temperature values.

LT A. J. SYCURO, JR.
OFFICER IN CHARGE
NAVAL WEATHER SERVICE
ENVIRONMENTAL DETACHMENT

• **See pages 24-25 this issue.**

Re MBEU Seal 15868, As You Were

NAS Lemoore—"Underwater Ejection," page 28 of the July '66 issue refers to replacement of MBEU seal 15868 with seal MBEU 18605 to insure watertight integrity of the Martin-Baker ejection gun. We have been unable to find authority for this change.

As a consequence, seal 18605 is being removed and replaced with seal 15868 in Pac activities to conform with ACSEB 34-61.

Are there any directives to the contrary?

LCDR W. B. YORK
ASO, VA-127

• As it turns out, you're doing the right thing in this case. The editors' note you refer to is not intended to imply that the seal MBEU 18605 is a part of ACSEB 34-61. The correct seal is MBEU 15868.Installation of MBEU seal 18605 came about with Martin-Baker's Design Change 57L of 6 Aug 1962. This drawing was furnished to prime contractors who in turn notified Supply of the requirement for the new seal. Prime contractors incorporated the new seal and O&Rs did likewise during PAR. Meanwhile, fleet activities reported difficulties with the new seal. Its small diameter allowed the seal to squeeze down the side of the cartridge and lodge between the breach and cartridge causing binding, jeopardizing watertight integrity and making cartridge removal extremely difficult.

As a result of a conference involving NavAirSysCom, NavAvnSafeCen and Martin-Baker representatives, the installation of seal 18605 will be discontinued and all ejection gun cartridge seals will be returned to the configuration directed by ACSEB 34-61 incorporating seal 15868. NavSysComRepLant message 051744 Oct 66 clarifies this situation.

APPROACH welcomes letters from its readers. All letters should be signed though names will be withheld on request.

Address: APPROACH Editor, U. S. Naval Aviation Safety Center, NAS Norfolk, Va. 23511. Views expressed are those of the writers and do not imply endorsement by the U. S. Naval Aviation Safety Center.

Replace Old Taxiway Lights

Washington, D. C.—An article titled "Tripped Up!" (August issue) describes the plight of a T-28 with a nosegear failure caused by a semiflush taxiway light.

The light is of ancient vintage having been designed well over 20 years ago. It projects two to three inches above the taxiway surface depending on installation and is a completely unacceptable obstruction to modern airplanes.

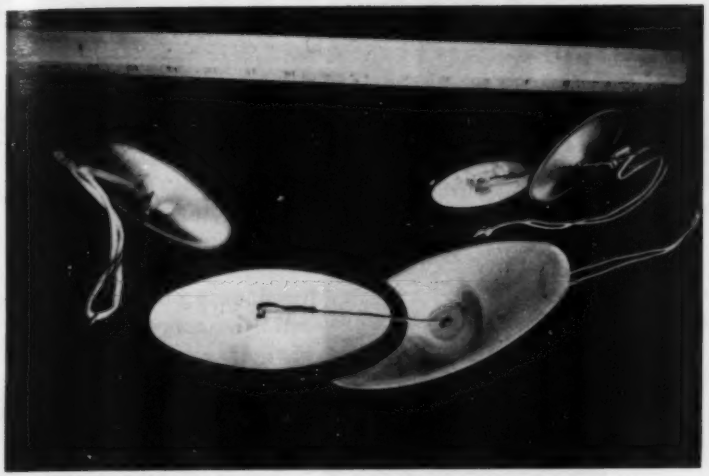
An improved light which projects one inch above the taxiway surface and is much more efficient has been available for about the past six years and is suitable for use in taxiways where aircraft are expected to taxi over the light.

The new light fits the same base as the old light so the change-over is merely the removal of the old light and substitution of the new. Where the old light is off the edge of the taxiway and not normally subject to rollover, it may be continued in service, but it should be replaced with the modern version as soon as feasible. The new light is the Type B-3 MIL-L-26202(ASG) and the Stock No. is RD6210-591-4116-D336.

It is hoped that the above information may be useful in preventing additional accidents of this type.

COMNAVSYSCOM

• So that no one misses the point, we repeat—old lights "should be replaced with the modern version as soon as feasible."



Raft patches are (l to r) 3 inches, 7½ inches and 5 inches in size.

Raft Patches

NAS Brunswick—Through the experience gained while in the billet of survival training officer and personal encounters (training ashore) with leaky rafts while attending the Tactical Air Command Sea Survival School at Langley Air Force Base, Va., I am convinced of the necessity for mechanical raft patches.

I combed the East Coast naval stations for information and found they were "not used any more", "only in the 20-man raft", but mostly, "I've never heard of them." It's true that they are in the 20-man raft, but only because the Navy procures these rafts from the Air Force. The newly formed Naval Sea Survival School at Pensacola, Fla., had heard of them but does not include them in their training. It would appear logical that these patches should be included as a standard piece of equipment packed with all rafts and readily available in all sizes in the supply system. The Air Force even includes the small patches in their seat survival kits.

I've acquired patches for my squadron and would like to pass on some information about obtaining them. There are three sizes: three inches, five inches, and seven and one-half inches. The three inch patch is in the supply system under the following number and title: KZ53440-494-0841 Patch, Mech, (flexible surface) three inch. The larger ones were acquired by open purchase from a sub-contractor; Philadelphia Manufacturing Company, Howard and Montgomery Avenues, Phila., Pa., Attention: Mr. Darlington or Mr. Startzman, Phone: Area Code 215 GA3-4200.

LTJG JAMES C. SPRINKLE
PATRON 23

• Thank you for your material.

Division Of Public Documents
U. S. Government Printing Office
Washington, D. C. 20402

Please send APPROACH (NavWeps 00-75-510) for one year to the following address. Enclosed is a check or Money Order for $3.50. ($4.50 for foreign mailing)

Name .....

Address .....

City ..... State ..... Code .....

Seek Kit Fire

In the Letters to the Editor section of the November APPROACH, HMM-262, MAG-26 reported a fire in a SEEK-1 container when three matches ignited. The editors noted forwarding of the original report to the Naval Air Engineering Center. Here is NAEC's reply:

"As a result of this report, tests were conducted on similar matches to determine their ignition characteristics when subjected to either elevated temperature or a condition of excessive vibration.

"Matches packaged as prescribed in the procurement specification for the SEEK-1 kit were found to withstand temperatures of 250°-300°F. before self igniting. These temperatures probably exceed any experienced operationally, especially since the SEEK-1 is normally worn by the pilot. Various stages of melting of the thin plastic covering of each match does occur earlier, however, and first evidence of softening begins at about 150°F. Complete destruction of the plastic film only exposes the matches to each other and does not cause ignition.

"To observe the effect of vibration on matches having no plastic film protection (as in the case of film destruction in high heat) and with match heads making direct contact, a two-hour vibration test was conducted. No ignition occurred and the match heads completely disintegrated due to the abrasion of one match on another.

"In view of these laboratory studies, it is hard to conceive the condition which may have led to the reported fire especially in view of the fact that only three of the six matches burned once ignition started."

(ACEL requested that MAG-26 forward the kit for study.)

Strobe Light

FPO, New York—At present, the strobe light is literally of no value when it comes to a light for finding things in a life raft or finding one's way in a survival situation at night. Why not widen the present case and install a one-cell pencil flashlight on the side?

RM2 D. E. CLOUSER
CAC-11, VP-10

• The strobe light is not designed to help the survivor find things or make his way in the dark. Its purpose is to aid searchers in locating the survivor. Reliable, effective, simple, small and as lightweight as possible, it comes as near to fulfilling its purpose as anything yet devised, in our opinion. We do not think that adding a penlight would be an improvement. The penlight can be carried easily in a flight suit pocket or on the survival vest.

Vol 12 **approach** No 7

Our product is safety, our process is education and our profit is measured in the preservation of lives and equipment and increased mission readiness.

Contents

1. Why Midair Collisions?
   By Earl J. Sands, PH.D.

6 It Could Ruin Your Whole Day
   By LCDR Donald H. Gehring

10 'You Too, Can Be a 97-Pound Heavyweight!'
   By Capt Roger G. Ireland, MC

17 Safety During Wartime
   By Capt. J. J. Zarriello

18 Mixed Emotions

24 Wind Chill Chart

26 A Matter of Weight
   By John Christiansen

31 Thrilling the Folks

32 And the Band Played On

36 The Right Fasteners are a Flyer's Best Friend
   By Edward F. Gowen, Sr.

43 Input Accuracy . . . The Heart of 3-M

45 3-M is Here

DEPARTMENTS

34 Flight Surgeons' Notes

46 Letters

IBC Lift and Drag

NavWeps 00-75-510

CREDITS

Cover: RA-5C Painting by Robert Tourt, Courtesy North American Aviation, Columbus, Ohio.

Purposes and policies: Approach, published monthly by the U. S. Naval Aviation Safety Center, is distributed to naval aeronautical organizations on the basis of 1 copy per 10 persons. It presents the most accurate information currently available on the subject of aviation accident prevention. Contents should not be considered as regulations, orders or directives and may not be construed as incriminating under Art. 31, UCMJ. **Photos:** Official Navy or as credited. Non-naval activities are requested to contact NavAvnSafeCen prior to reprinting APPROACH material. **Correspondence:** Contributions are welcome. The editors reserve the right to make editorial changes which they believe will improve the material without altering the intended meaning. Reference to commercial products does not imply Navy endorsement. Views of guest written articles are not necessarily those of NavAvnSafeCen. **Distribution:** If you are receiving the magazine free because of military or commercial contract status with the Navy . . . Requests for distribution changes should be directed to NavAvnSafeCen, NAS, Norfolk, Va. 23511. Phone: Area Code 703, 444-4279 (days), 444-3520 (Nights, weekends, Holidays) Att: Safety Education Dept., IF YOU ARE A PAID SUBSCRIBER, address all renewals and address changes to Division of Public Documents, Washington, D. C. 20402. **Subscriptions:** Single copy 35 cents; 1-year subscriptions $3.50; 2 yrs., $7.00; 3 yrs., $10.50; $1.00 additional annually for foreign mailing. **Printing:** Issuance of this periodical approved in accordance with Department of the Navy Publications and Printing Regulations, NAVEXOS P-35. Library of Congress Catalog No. 57-60020.

48

RADM Paul D. Buie, Commander, U. S. Naval Aviation Safety Cen

CDR Stephen Oliver, Head, Safety Education Dept.
A. Barrie Young, Jr., Editor
LCDR J. B. McDaniel, Managing Editor
LT R. F. O'Connor, Flight Operations Editor
J. H. Reinburg, Research Editor
J. C. Kiriluk, Maintenance/Ass't Managing Editor
J. A. Bristow, Aviation Medicine/Survival Editor
Robert Trotter, Art Director
Blake Rader, Illustrator
DMC F. L. Smith, Production Control
PHC Harry Culbertson, Photographer
JO2 P. D. Lucas, Editorial/Production Associate

Contributing Depts.
Accident Investigation, Head, CDR C. T. Roberts
Aero-Medical, Head, CAPT R. E. Luehrs, MC
Analysis and Research, Head, CDR D. G. Patterson
Maintenance and Material, Head, CDR V. R. Knick
Records and Statistics, Head, CDR T. R. Overdorf

ACCENTUATE THE POSITIVE

Fatigue was determined to be a factor in two very recent major aircraft accidents. The use of a bit of judgment and attention to detail in scheduling could have precluded this problem. Commanders are enjoined to stress the importance of this and take steps necessary to prevent pilots being scheduled for an early-early and a late-late without a period for adequate rest in the interim.

A particularly noteworthy endorsement by the Naval Aviation Safety Center concerning one recent accident relating to rate-of-training during the existence of qualified supervisory personnel deficiency, is quoted for policy guidance:

". . . during the training process, particularly in a high performance aircraft such as the F-4B, supervisors must *not* assume a pilot's previous accumulation of knowledge, experience or self-discipline. If the training environment does not permit close monitoring of flight operations, then pilot training should not be conducted. . ."

Commanders will insure that all training, on-the-job-training in maintenance, line operations and flight, is delayed until favorable conditions for such training again exist. We must not rush ourselves to death!

As has been pointed out before, most accidents are the result of an accumulation of events, any one of which having been corrected at a given point in time, would have prevented the accident. We recently lost a pilot apparently from this cause. Be alert for events stacking against you and break the chain early by taking positive corrective action. Stack the events, like the cards, in your favor, not against you.

Adapted from a Command Safety Message

LIFT AND DRAG